This is a digital copy of a book that was preserved for generations on library shelves before it was carefully scanned by Google as part of a project to make the world's books discoverable online.

It has survived long enough for the copyright to expire and the book to enter the public domain. A public domain book is one that was never subject to copyright or whose legal copyright term has expired. Whether a book is in the public domain may vary country to country. Public domain books are our gateways to the past, representing a wealth of history, culture and knowledge that's often difficult to discover.

Marks, notations and other marginalia present in the original volume will appear in this file - a reminder of this book's long journey from the publisher to a library and finally to you.

**Usage guidelines**

Google is proud to partner with libraries to digitize public domain materials and make them widely accessible. Public domain books belong to the public and we are merely their custodians. Nevertheless, this work is expensive, so in order to keep providing this resource, we have taken steps to prevent abuse by commercial parties, including placing technical restrictions on automated querying.

We also ask that you:

+ *Make non-commercial use of the files* We designed Google Book Search for use by individuals, and we request that you use these files for personal, non-commercial purposes.

+ *Refrain from automated querying* Do not send automated queries of any sort to Google's system: If you are conducting research on machine translation, optical character recognition or other areas where access to a large amount of text is helpful, please contact us. We encourage the use of public domain materials for these purposes and may be able to help.

+ *Maintain attribution* The Google "watermark" you see on each file is essential for informing people about this project and helping them find additional materials through Google Book Search. Please do not remove it.

+ *Keep it legal* Whatever your use, remember that you are responsible for ensuring that what you are doing is legal. Do not assume that just because we believe a book is in the public domain for users in the United States, that the work is also in the public domain for users in other countries. Whether a book is still in copyright varies from country to country, and we can't offer guidance on whether any specific use of any specific book is allowed. Please do not assume that a book's appearance in Google Book Search means it can be used in any manner anywhere in the world. Copyright infringement liability can be quite severe.

**About Google Book Search**

Google's mission is to organize the world's information and to make it universally accessible and useful. Google Book Search helps readers discover the world's books while helping authors and publishers reach new audiences. You can search through the full text of this book on the web at `http://books.google.com/`

LANE MEDICAL LIBRARY STANFORD
2 45 0062 0253

LANE

AL LIBRARY

COOPER LANE FUND

# MEDICAL AND SURGICAL

USES OF

# ELECTRICITY.

# MEDICAL AND SURGICAL

USES OF

# ELECTRICITY.

# MEDICAL ELECTRICITY:

EMBRACING

*ELECTRO-PHYSIOLOGY*

AND

## ELECTRICITY AS A THERAPEUTIC,

With Special Reference to Practical Medicine:

SHOWING

THE MOST APPROVED APPARATUS, METHODS AND RULES,
FOR THE MEDICAL USES OF ELECTRICITY
IN THE TREATMENT

OF

## NERVOUS DISEASES.

BY

ALFRED C. GARRATT, M.D.,

FELLOW OF THE MASSACHUSETTS MEDICAL SOCIETY; MEMBER OF THE AMERICAN MEDICAL ASSOCIATION.

LANE MEDICAL LIBRARY
7695
SAN FRANCISCO

Third Edition, Revised and Illustrated.

PHILADELPHIA:
J. B. LIPPINCOTT & CO.
1866.

LANE LIBRARY

Entered, according to Act of Congress, in the year 1866, by
ALFRED C. GARRATT,
In the Clerk's Office of the District Court of the District of Massachusetts.

ELECTROTYPED AT THE
BOSTON STEREOTYPE FOUNDRY,
No. 4 Spring Lane.

.24.
866

TO

# JOHN HOMANS, M. D.,

PRESIDENT OF THE MASSACHUSETTS MEDICAL SOCIETY, MEMBER OF THE AMERICAN MEDICAL ASSOCIATION, MEMBER OF THE SOCIETY OF MEDICAL IMPROVEMENT, ETC.,

TO WHOM, DURING MANY YEARS OF PROFESSIONAL LIFE, IT HAS BEEN MY HAPPINESS TO LOOK AS A REVERED FELLOW OF OUR NOBLE ART,

*MY COUNSELLOR AND FRIEND,*

WITH FEELINGS OF ADMIRATION FOR HIS LIBERAL PRINCIPLES, PROFESSIONAL INTEGRITY AND FORECAST, AND WITH NO LESS GRATITUDE FOR HIS EXERTIONS IN THE GENERAL CAUSE OF

Medical Science,

THIS HUMBLE THOUGH ARDUOUS WORK

IS GRATEFULLY DEDICATED.

# PREFACE.

MEDICAL STUDENTS: For you have I prepared this work on Electro-therapeutics, including Electro-physiology, Electro-pathology, and Electro-diagnosis. It is aimed to be a plain, practical, and systematic work. *Electricity* and *Vitality* are now known to be intimately related. It is an acknowledged fact, that medical men, at least, are not as familiar with the links of that relationship as they might be, and should be. Electricity, in its different forms and manifestations, is as absolutely and minutely concerned, according to their respective "laws of action," in every life with health, growth, disease, and struggle for the recovery from disease, and in death, as in the grand chemistry of inanimate nature, or in the greater and mightier forces of gravitation and planetary revolution.

*Vitality* is more than Electricity. Life is electro-chemistry *vitalized*. This greatest force of nature, viz., Electricity, which also holds such varied and powerful influences over life, health, and disease, does assuredly command our more attentive study, in connection with other rational medicine.

The *progress* of medical science, during the past half century, has brought us into new and closer relations with almost all other departments of *physical science*; but with none, however, in so intimate and indissoluble a manner as with this of Electricity. Hence it has come to pass, says De la Rive, that the study of Electricity, as it relates particularly to medical knowledge, and *practice*, has become an absolutely indispensable study for every one who practises, teaches, or in any way cultivates science, and wishes to be *booked* up to the age and day. So also of the trades, arts, and sciences; — to the pharmaceutist and chemist, as well as the natural philosopher; to the dentist and physiologist, as well as to the geologist; as much to the engineer and artisan as to the physician; — all, all have electric forces and phenomena to deal with, and consequently each has need of becoming familiar with them; at least so far as they relate to the given trade or practice, he should be enabled to interpret them, to meet them, and to turn them to good account.

The subject matter of this work, therefore, embraces more aspects than one. It presents you not only with a reliable and potent class of remedies, (together with the best *methods* for using them,) and fairly opens a field of improved treatment for many nervous derangements and diseases, but it also affords an instructive *phase* of nature in growth, waste, and repair; in cause and cure, or disease and remedy, and of *nervous phenomena in particular*; thus throwing peculiar light on the whole range of the healing art. Indeed, it appears to me, that those who love, teach, or have to do with the natural sciences, or

who wish "to know themselves," or the philosophy of our being, particularly if medical men, — I say, no such person can possibly study this subject without the profoundest interest and substantial improvement. Physicians, of all men, should be frank towards each other. More than other men, we are dependent upon each other for facts, from which, when sufficiently numerous, we must reason up to generalization, and thus slowly discover and establish the laws of nature, as the rules of our ethics, to *comprehend* life, disease, and death. Isolated phenomena or experiments, nay, even a life-long experience in medicine, is worse than unavailing, so far as it affects knowledge and *improvement*, if it is pursued only by a dogmatic routine, or in support of a foregone conclusion. Only the one thing in that case is clearly seen; and that is, just what had always been expected, "*according to the creed.*" The reasonable means, or the successive steps to the end obtained, are entirely overlooked. Let this, therefore, be our caution. We must hold, that the uncompromising lessons of careful and practical induction should attend our every step, as *special students* in this interesting but *intricate* department of science and medicine; for no conclusion has ever stood the test of time, and gained general consent with the intelligent, that is not strictly in harmony with the laws of nature, and with the moral laws of God.

The author, being profoundly convinced of the efficacy of electric currents *as a remedy*, capable of producing, often, a *radical cure*, especially in nervous affections, bespeaks a generous and impartial reception by our American medical world, of what is already achieved for and in electro-physiology and electro-therapeutics; i. e., as to what relates, in a scientific sense, to the *medical uses* of Electricity.

When Physiology is usually treated of as a science, and presented as a part of the foundation of a thorough medical education, then, of course, it embraces the whole organic nature. All classes of organized beings and organisms have there an appropriate chapter, according to the mode of development, &c. But here we give place to one grand *phase* of physiology and pathology, as a somewhat new, but soon to be realized, *indispensable help-science* to the healing art. All medical practitioners may not wish to give their time and attention, personally, to the employment of any electric apparatus; and but few may wish to make those diseases called "*Neuralgies*" and "*Palsies*" their exclusive practice; but still, no one member of an educated medical profession can nowadays be uninformed in normal and abnormal nervo-electric phenomena (that is, in electro-physiology and electro-pathology) without discredit to himself and injustice to his patient.

Pathology, young as it is, has been already admitted as an accredited witness of very peculiar importance. But a few years since, and we know that there was no professor's chair for it in any of our medical schools. Now, who does not know that it is a very "law and testimony"? Yet post-mortem and ocular pathology gives us but comparatively little insight into the deviations and lesions of the human nervous system. But, at this very weakest

point in all medical science, important yet delicate, elaborate and yet intricate as it is, Electricity comes to our aid and elicits, — *has* elicited, certain uniform phenomena, — already a "law and testimony," so far as ascertained, that can be derived from no other source. Significant facts like these do certainly demand of medical men a careful attention. Because we do not know more, or all, is certainly no good reason why we should not avail ourselves of what is already positively discovered. Much in this department of medical research will yet, ay, will *soon*, be accomplished; and brilliant will be the achievements.

The very abridged manner and immethodical style of the few works that have appeared in this country, or even in the English language, on the medical employment of Electricity, have never yet enabled the medical profession generally, particularly that of this country, to seize upon these telling facts understandingly, so as to bring them to bear upon clinical practice. On the other hand, the more complete treatises on physics enter too much into detail on Electricity, in its own wide realm, as a force of nature, or as a physical force, or in speculations upon these, for persons who do not desire to make this their particular object of labor and pursuit.

A systematic work on the medical and surgical uses of Electricity, containing clear and practical directions as to *where*, *when*, and "*how*," to employ Electricity as a remedy, (embracing at the same time the condensed scope of those natural, accidental, as well as artificial electric influences that affect life and health,) has long been greatly needed; and of late urgently *requested of the author*, by many distinguished members of the most venerable medical association in America, to fill, in some degree, this deficiency in our medical literature. True, we have had published in this country some small, yet valued treatises on this subject — one by Dr. Golding Bird; another by Dr. W. F. Channing. But these pioneer works were rather "evidence and argument," to exhibit and convince of what has, might, and would be accomplished by the medical uses of Electricity, rather than giving any philosophic and rational *exposé* of the *methods of doing it*. Therefore what has been done by the agency of Electricity, in the way of *remarkable cures*, empirically or otherwise, if the *modus operandi* is not also clearly given, is purposely excluded from this work. The author has aimed to confine himself to gleaning from the highest practical authorities, and the comparing of these with his own clinical experiences, then classifying and arranging the subject matter, so as to present the whole range of electro-therapeutics on a more systematic and scientific basis.

Perhaps it is scarcely necessary to add here, (except to forestall unnecessary and detracting criticism,) that the author has unavoidably employed the ideas often, as also the language, of others. In a work like this, based as it is *in natural science*, with a limited special literature, every one must know is but the embodying of the best of all high authority, while but a portion of the whole is truly original. Our freshest knowledge has its origin in the teachings and well-known writings of the world's best philosophers; which, after being

applied in this department of medical practice, becomes, in part, but a modified transcript of the originals; but in another sense, and that the more practical, there must be conceded to be a large share of originality pervading this whole work. In fine, the author has perseveringly labored to gather whatever is known on this subject, found in any language, *that is practical;* and that from the highest sources, and from first hands. Here he has been greatly favored by the kindness of Professor Scherb and Mr. Frederick Penard, in their readings and translations out of the Italian and German. The best of authorities have been consulted, and each has given his testimony on this part or that. From the writings of Galvani, Volta, Humboldt, Nobili, Marianini, Matteucci, Magendie, Becquerel, Marshall Hall, and Faraday; from De la Rive, Duchenne, Middeldorpff, Remak, Todd, Alfred Smee, and Brown-Sequard; from these and others have we recorded individual researches of the most intrinsic significance, as well as their individual opinions. But where quotations are made, they are duly acknowledged. Thus we find a rich field of facts for us, which have been accumulating in variety, and maturing by corroboration for the past half century. But the right or wrong interpretation of these facts, or their apparent conflicts, &c., we must leave for others to discuss. *Success in practice,* not theory, is our aim.

A work of merit, I feel satisfied, is not in the end injured by criticism, if fairly done; but this is too much to be expected every where. The author, however, cannot be surprised. No one sees so well as himself how little he feels that he knows of the length and breadth of this intricate and extensive subject; although he may be permitted to add, that he has had the honor and the advantages of the personal instructions, conversations, correspondence, and encouragements of some of the most renowned philosophers and truly experienced "medical electricians" in Europe; to which, during many years of this special practice, has also succeeded a no small clinical experience in the treatment of Nervous Disorders, and in the medical and surgical uses of all forms of Electricity — static, voltaic, galvanic, and faradaic.

But to the subject directly: Careful and repeated observations of Electro-physiologic, pathologic, and therapeutic *phenomena* very soon leads us to discover *two* prominent and distinct points of view. One of these comprehends the General Laws of Electricity, in this respect; the other view comprehends the *results* arising from the manifestation of "animal electricity" in living bodies, and the action of the various forms, and methods of application of electricity, upon these bodies, and their native currents. The facts and deductions of the one require to be studied, to understand those of the other. Anatomy and physiology, also, need to be viewed through this medium, as well as from other stand-points, in order to get a true stereoscopic view of the philosophy of life, the laws of disease, and the catastrophe of death.

Under the *first division*, then, we must become familiar with the different kinds of Electricity, as Natural Electricity; also Electricity as manifested by the disturbances of nature; also with Static and Dynamic electricity, so far as

they relate to our subject. Hence both the natural and artificial sources of electricity, together with the general and specific laws that regulate the given transmission of this subtile agent through the different *living* tissues, in *health*, and in *disease*, must be successively passed in review. Next comes the early history of the medical and surgical uses of electricity, Atmospheric and Terrestrial electricity, with Magnetism, Frictional Electricity, Galvanic and Electro-magnetic Currents, together with a description of all the apparatus for conveniently producing and regulating the *quantity* or the *intensity* of currents; all of which must be clearly exhibited to be easily understood. This, therefore, will compose the first three Chapters of this work.

Under the *second division*, as we may call it, we need to become no less familiar with the phenomena of Electro-physiology, in all its wonderful teachings, even from *cell-life*, electro-biology, — the nervo-electric batteries of human life, the effects of Atmospheric Electricity, — up to Animal Electricity, and the action of artificial currents, when directed for diagnosis, surgical and other remedial purposes. Diagnosis of diseases, and the Fundamental RULES for the rational employment of electricity in practice, must be seen in panoramic review. Then we examine the broad range of nervous affections, which are classed *here* under Hyperæsthesia, as, exalted nervous action, and painful affections. And another large class, under Anæsthesia, as, diminished nervous action, and all paralytic affections. Next in order will appear the Spasmodic affections, Midwifery, Surgery, Dentistry; and then the *special* cases, as suspended animation, anomalous nervous derangements, in which some given form of electricity, or particular method of applying it, has been found most beneficial and successful. Such, and more, will occupy the seven other chapters of this work, which, as a whole, I designate as Electro-therapeutics, — all of which will be found illustrated with ample *Cuts of Apparatus*, on the one part, and fine *Anatomical Cuts* of the Nerves and Muscles, &c., on the other; so as to be to the medical student as complete a work on this whole subject of which it treats as possible with our present knowledge, or as can be found in any language. Should life and opportunity be granted, the author proposes to prepare, at no distant year, a second volume, that shall be a counterpart to this — a sequel, embracing his clinical experiences, showing not only the results of purely electric treatments, but also showing the efficacy of the electric *séance*, in given cases, *when combined*; that is, simultaneously employed with the ordinary prescriptions of medicines.

When I first directed my entire professional labors to this difficult department of *special* medical practice, (after having been engaged in the general practice of medicine for nearly twenty years,) to speak mainly in the words of another, — I did so with the fullest sense of their importance, in two relations: first, as they related to my own future career and reputation; second, as they related to the advancement of the healing art, and the immediate relief of a no small class of otherwise unreached, afflicted, and suffering persons. I was fully aware that my position, my views, and aims might excite misappre

hension, because the hitherto very general association of the empirical uses of electricity, with quackery, throughout the length and breadth of our country, would naturally lead to some erroneous verdict, at least until my true position might be directly and definitely defined.

But one word further. Our art is *one* art. Each branch is but a part of the whole, and simply, "*e pluribus unum.*" It is too late to be sticklers for creeds or isms, for pathies or systems; only let each be honest and in earnest in his professional sphere. The author is desirous that this should no longer be termed a "*System*" of practice, but merely *the electric remedies*, &c., and that we take special pains to eradicate those false notions from the minds of the people.

I wish here to call particular attention to the fact, that almost no allusion is made in this work to the simultaneous employment of medicines with electric treatments. This is *purposely* omitted; but it must not necessarily follow that it is to be omitted in practice, if we wish to gain the greatest possible amount of improvement for the patient in the least possible time. Indeed, it will often be noticed that a skilful use of electric currents will *quicken* the action, and *heighten* the effects of internal medicines. Often, cases will be presented that promise success only in this way.

Again: like many other potent remedies now, as heretofore, employed in the treatment of diseases, electricity is greatly valued for its given effects, in certain cases, by a small portion of the profession who have thoroughly investigated it, among whom are some of the most distinguished names; while another portion of the profession, equally respectable, think but little of it; and others there are who discard it altogether. But when it is shown that the nerves, muscles, and many of the secretions can be more surely and more uniformly called into their natural action by means of electricity than by any other known agent, and that the *degree* and *kind* of that effect is *widely different*, according to the form, quantity, or intensity of the electricity employed, and that again modified *as widely*, according to the *methods* of administering the dose at each *séance*, it is to be expected that the existing differences of opinions as to the healing power, or the manageable and remedial value of electricity, will be more nearly harmonized, and that on an intelligent basis.

It must not be thought certain that the electric current exercises an inworking influence only on or through the nerves and muscles. It is, on the contrary, my intention to aid medical men to become familiar with the idea, that all textures of the living animal body, being saturated, as they are, with the saline solutions of the blood and other secretions of the animal economy, are peculiarly accessible to the chemical and mechanical workings of the static, galvanic, and electro-magnetic currents. However, to my own mind, it is only by the most minute and slowly maturing experiences in the analogous workings of these currents in different living tissues, that insight and confidence can be obtained, which are so necessary for the rational application of electric currents for curing diseases. I trust this work will present a phalanx of facts, as well as many original, practical directions for obtaining physio-

logical and therapeutical results, that will be found worthy of a candid attention, and lead on to fresh researches in this inviting department of medical science.

Finally, the author of this work has aimed by directness, thoroughness, and extent of practical research, thus presented by himself or by accredited authorities; by ample plates of apparatus, and of anatomy; by great simplicity in style, and freedom from technicalities as far as possible, (also by *term* Explanations,) to present this whole subject of *Medical Electricity* in so clear and simple a manner as to be readily understood by any one of ordinary intelligence; hoping it may invite into this hitherto neglected, but intensely interesting and profitable study of Electricity, as it relates to human life and health, *to the cause and cure of disease*, all ranks of the medical profession, as well as help to initiate the younger candidates for its labors and its honors, in years to come, to a still more *rational view* of diseases and their remedies;— to all of whom, or whosoever reads, it may prove an exposition of this subject at once elementary, practical, and substantial.

# PREFACE TO THE THIRD EDITION.

THE present treatise, *De Medicinâ Electricâ*, — concerning Electricity as a remedy, — with special reference to practical medicine, although only the third edition of my work on Electro-therapeutics, may be regarded in truth, and indeed for all practical purposes, as mainly a new book in this department of medicine. It is given a new title, for it is largely composed of new and exclusively practical matter, adapted to the wants of the busy practitioners of medicine, midwifery, surgery, and dentistry.

When the preparation of the first edition was solicited for the press, by prominent American medical gentlemen, soon after my return from Europe in 1857, my task at that time seemed to be: First, to show that electricity, as provided by the various kinds of apparatus, if employed under certain conditions respectively, was truly a remedial *power;* also, that from certain wrong manipulations, or from want of manipulation, it would certainly fail, and might even be capable of doing harm, instead of good. It is surely not less essential to the true progress of our science and art, to remove errors than to establish truth. Therefore, to substantiate these propositions, which appeared to be new to most medical men in this country at that time, many quotations of, and repeated references to, various highly accredited authorities were made.

Second, to show, over and beyond the fact, that it was not haphazard, nor powerful *electricity* in itself considered, as any way applied to the organism, that could be relied upon as a rational remedy, but that it was the *method* and *skill* of application, and of combination, and alternation with other known remedies that gave the success; therefore, that electricity, in any form, should never be employed, excepting it be applied understandingly, prudently, and *methodically*, according to the apparatus from which it is procured, and the disease for which it is used.

Third, to show some general principles, as also some *specific rules*, as were then known, for using the currents of the common batteries and machines, — *induction apparatus*, — such as are generally found in every part of our great Union.

Judging from the rapid and extensive sale of the first and second editions, and from the many kindly communications the author has received from learned men in Europe, but more particularly from medical gentle-

men in all parts of our own country who are untainted with quackery, some of them being connected with our largest and best medical schools, as well as those held high in public esteem for sagacity and skill, and are in extensive practice, — it is conceded to have accomplished a very convincing work. For these reasons also, some several hundred pages of that portion of the book is thrown out, to be replaced by twice as many pages prepared from actual experience in practice, which are now added. Every portion has been carefully revised, and every care has been taken to embody the results of researches, and of all experience in practice to the present day. For this reason, too, the book has been out of print for nearly two years.

The successful study and improvement of the uses of electricity as a remedy, of course require time and attention; not this only, but a devotional love for medical practice, as well as for philosophical research, that commands untiring attention, and no little degree of systematic precision, and delicacy of manipulation in conducting all the treatments so as to obtain definite results. In fact, the whole matter depends upon attention and accuracy. It admits of no negligence, no mistake. The clear and decisive character of the cases, and their treatment, herein presented, will, I trust, prove sufficient to establish the utility of the methods adopted, as well as the *rationale* of the principles advanced, upon which the peculiar method of treatment is founded. To my own mind, there is no ambiguity in these results.

Finally, in order to set forth most clearly the *limitations*, as well as the applications, of this great class of electric-remedies, — in other words, to show where and when, and where not and when, not to use it, — the plan is forced upon me of preparing *a conjoined work on nervous and chronic affections*. But having no sort of theory to press, and wishing to avoid the introduction of any vague statements or hypothetical conclusions, and most of all being desirous of avoiding etiological and physiological discussions, in a work I have intended, and have so labored to make, especially practical, that not a paragraph is admitted that might be so interpreted.

We do not advocate, with Dr. Inman, "that the theory and practice of medicine as a whole ought to be based upon *alterations in power* or vital force, rather than in changes of structure;" but we do thank him for presenting this proposition so clearly and forcibly before us, that we may be reminded of the teachings of Elliotson, Alison, Copeland, Watson, and our own James Jackson, and that there is a large class of diseases which must be viewed only in the light of *altered vital force*, whether it begins in the nerves, the blood, or the tissues; and the treatment, to be judicious, must be directed accordingly. There may occur fevers and inflammations even, that will not bear the antiphlogistic treatment, but which, as is well known, are rapidly cured by the opposite course; so no shade of a new *pathy*, nor *ism*, is to be thrust upon the medical profession in this revised volume, but simply the *methods* insisted upon for the more reliable and extended use of *a power*, that doubtless can be made a source of health, and a very fundamental in therapeutics.

Although the author, after nearly nineteen years of general practice, has devoted himself *exclusively* in later years to the study abroad, and treatment at home, of nervous and chronic affections, mainly by means of the various forms of electricity known as *galvanism* and *faradaism;* and being conscious, as he certainly is, that it is only through such facilities as this specialty alone can afford, that he is enabled to put forth this *practical* work, — still he is no advocate for the general rush there seems to be, in some quarters, towards specialties. He is quite sincere in indorsing the views of Dr. Meigs, of Philadelphia, in regarding the propensity, or fashionable tendency, to specialization among medical men, as a thing most injurious to the profession — "which ought to be a whole in the whole, and a whole in every part." Dr. Hutchins, an English surgeon, says in substance, that arrangement and system are undoubtedly the very sinews of success. It would certainly appear likely that nothing could better tend to ecomomize the labor of medical investigators, and facilitate their researches, than the grouping and classifying of the materials of which and on which they have to work. So far as specialties represent a reasonable system of classification, so far they are useful to science. Unfortunately, however, it is quite impossible to carry this very far. Our existing specialties are chiefly founded on groupings, according to the organ or part affected; and this is most arbitrary and unnatural. Nature and disease persist in declining to allow the human body to be considered as other than the one whole, and as constantly permitting one and the same organ to suffer under the most varied and complicated influences. It is needful, therefore, to the truly successful specialist, that he thoroughly understands all the various phases of disease; and this necessity, imposes upon him that general course of study from which he cannot escape.

A medical student, not necessarily romantic, will conceive that he has a peculiar preference for some given department of medical practice. Perhaps it is because he understands that best, or most readily. Now, this is not peculiar to him, for it is the experience of nearly all men, and is therefore illusive; there being no substantial reason why he should become an exclusive specialist, or even neglect his general practice to give the most of his energies to this mere preference. Yea, let me advise my younger professional brethren, from a standpoint of experience, to be slow, and well advised, before choosing any specialty. But very few men are adapted to take a specialty, and fewer still succeed. If one has peculiar facilities by education, by position, or by providential surroundings, these might well influence a choice and decision; especially if he is a worker, and has rare and acknowledged talents, together with unfaltering patience and perseverance to pull at the same oar, with a cheerful and devoted spirit, all the days of his life. On these conditions we welcome him as a rare specialist, and trust that he will be a success for himself, for the public, and for the profession. But I must insist, that to make a good specialist, he certainly needs to be a good general practitioner first, and to have thus already acquired a fund of real practical experience.

Every duly qualified medical man, throughout our broad country, having the legitimate title of M. D., must be expected to be more and more, *ex officio*, qualified to perform and fulfil all departments and offices (specialties) in medicine, midwifery, and surgery. Yet there have been, more than at the present, special surgeons, and surgery itself was divided into specialties; and there are special men for dental operations, for eye affections, for midwifery, and diseases peculiar to females, &c. This probably will always be so among dense and cultivated populations. There doubtless will be other new specialties springing up, as the science and art of medicine advances. But what the author wishes to advocate, and influence others to advocate, as a principle, is, that it be our aim and conscientious labor to aid in qualifying each individual member of the medical profession, in every department of the healing art, so that specialties may be comparatively few in number, because not required. This we conceive to be the true conservative principle it is our professional duty, privilege, and pride to inculcate.

ALFRED C. GARRATT,
9 HAMILTON PLACE.

BOSTON, *March* 1, 1866.

# CONTENTS.

## CHAPTER I.

*Natural Electricity.* — Its Characters. — Sources of Electricity. — Thales the first Discoverer. — Electricity at Rest. — In Motion. — Nature of Electricity. — Franklin's Theory. — Symmer's. — De la Rive's. — Thermo-electricity. — Thermo-cube. — Static Electricity. — Dynamic Electricity. — Laws of Electricity. — Sparks and Currents. — Atmospheric Electricity. — Franklin's great Experiment. — Sparks from the Clouds. — The Clouds. — Thunder Storms. — Fogs. — Relation of Electricity to the Air and the Earth. — Aurora Borealis. — Meteorology. — Storms. — Storm Tables. — Atmospheric Hydrometer. — Difference between Electricity and Magnetism. — Weather Prognosis. — Lightning. — Safety from Lightning. — Effects on the Human Organism. — Effects of Atmospheric Electricity on the Human Organism. — As regards Births and Deaths. — Electric Changes the Cause of Epidemic Diseases. — Researches of Sir James Murray. . . . . 25

## CHAPTER II.

*Early History of the Medical Uses of Electricity.* — One Hundred Years ago. — Pliny. — Discovery of the "Leyden Vial." — First Trial of Shocks. — Treatise by Dr. Mauduit in 1778. — Electropathy advocated in 1802. — Electric Bath. — Medicines placed in the Prime Conductor. — The prevailing Superstition of that Age. — History of the Discovery of Galvanism. — Early Medical Uses of Galvanic Electricity. — Animal Electricity. — Galvani's Frog. — His Nervo-electric Theory. — Convulsions produced in a dead Frog. — Professor Volta's Views of the Phenomenon. — Views of Alexander von Humboldt in 1799. — Volta discovers the *Pile*. — Sir H. Davy's Researches. — Discussion between Galvani and Volta. — Dr. Aldini's Experiments. — Nobili's Researches. — Vallio's Researches. — History of Electro-physiological and Electro-therapeutical Researches. — Views of Ritter. — Researches of Marianini and Nobili. — Researches of Dubois-Reymond. — Researches of Matteucci and Becquerel. . . . . 83

## CHAPTER III.

*Electro-Physiology.* — Electro-biology. — Cell Life. — Nervo-electrical Batteries of Animal Life. — Researches of Matteucci and Alfred Smee. — Minute Structure of the Nerve-fibrils *illustrated.* — "Hallerian Irritability." — Elementary Fibres of Muscles *illustrated.* — Electro-physiological Researches and Creeds. — Animal Electricity as observed in Fishes. — The Eel and Torpedo *illustrated.* — Animal Electricity as observed in Animals and in Man. — Electro-physiological Laws as deduced by Marianini, Matteucci, Dubois-Reymond, De la Rive, Bec-

querel, Marshall Hall, and Brown-Sequard. — The minute Terminations of Motor Nerves in Muscle Fibres *illustrated*. — Laws and "General Principles" deduced from Electro-physiology. — Electro-physiological Deductions of Nobili. — Volta's Experiments on the Frog. — The Effects of Heat and Cold on the living Animal Nervo-electric Batteries. — Osmotic Force. — Electrolysis and Catalysis. — Special Electro-physiology. — The Human Brain *illustrated*. — Effects of Electricity on the Brain. — The *Vital Spot*. — The Spinal Column, Brain, and Spinal Cord, and the Sections of the Spinal Cord all *illustrated*. — Effects of Electricity on the Cord. — On the Organs of Sense. — The Ear and Auditory Nerve *illustrated*. — Effects of Electricity on Seeing. — The Iris. — Hearing. — Smelling. — Tasting. — Effects of Electricity on the Sentient Nerves. — On the Motor Nerves. — On Mixed Nerves. — On the Sympathetic Nerves *illustrated*. — "Regions" of the Human Body. — Effects of Electricity on the Intestines, Uterus, and Secreting Organs. — Organs of Digestion *illustrated*. — Effects of Electricity on the Heart and Blood-vessels. — On the Blood and Fibre-cells. — Effects of Electricity on the Muscles *respectively*, physiologically. — Muscles of the Face and Neck *illustrated*. — Muscles of the Back *illustrated*. — Muscles on the Front of the Body *illustrated*. — Muscles on the Side of the Body *illustrated*. — Muscle-fibres and Fibre-cells *illustrated*. — Œsophagus. — Effects of the Currents. . . 109

## CHAPTER IV.

*Electrical Instruments and Apparatus for Medical Purposes*. — Three Classes of Instruments. — Electricity from Friction. — Electricity from Chemical Action. — Electricity from Induction. — Electrical Machine. — Leyden Jar. — Dischargers, Insulators, &c. — Galvanic Electricity and the Apparatus. — Volta's Pile. — Cruikshank's and other Batteries *illustrated*. — Galvanometer. — Galvanoscopic Frog. — Static Electricity as it relates to Medicine. — Electric Induction. — Direction of the Current. — Quantity and Intensity. — Electric Heat. — Induction Currents. — Discovery of Professor Oersted. — Discovery of Ampère. — The Astatic Needle. — Arago. — Sir H. Davy. — M. Nobili. — Researches and Discoveries of Professor Henry. — Researches and Discoveries of Professor Faraday. — Electro-magnetic Double Helix, with Clockwork. — Dr. Neef, of Frankfort-on-the-Main, *invented* the Automatic Vibrator. — Faradaic Electricity. — *Faradaic Currents*. — Electro-magnetism *illustrated*. — The Electro-magnet. — Magneto-Electric Portable Machine *illustrated*. — A great Variety of Electrodes *illustrated*. — Current-breaker for Dentists' Use. . . . . 310

## CHAPTER V.

*Methods* for the Medical Employment of Electricity. — Precautions. — Methods for using Static Electricity. — Methods for using Dynamic Electricity, or Currents. — Methods with the Primary Current of Galvanism. — Methods with the Secondary Current of Faradaism. — Laws of Muscle Contraction as deduced by Dr. Remak. — *Labile* Electric Current Workings. — *Stabile* Electric Current Workings. — Volta's "Alternatives." — The "Tetanus of Ritter." — Polar Workings. — Intra-polar Workings. — Extra-polar Workings. — Polar Alternatives. — "Alternations of Ritter." — Labile Muscle Contractions. — *Rules* for managing the *Seance*. — Duchenne's Methods. — Faradaization. — Electro-chemical Baths. — Magnets as a Remedy. — Æsthesiometer for Diagnosis. — Electro-muscular Test. 381

## CHAPTER VI.

*Hyperæsthesia.* — Exalted Nerve Actions and Pains. — "General Principles" as regards Nerves in Health and Disease. — Sciatica. — Different Forms of Sciatica. — Sciatica as Type of other Neurotic Affections. — Rheumatism. — Gout. — Hysteria. — Muscular-hyperæsthesia. — Muscle-pains. — Cephalgia. — Rachialgia. — Epigastralgia. — Pleuralgia. — Thoracalgia. — Cœlialgia. — Melyalgia. — Methods of Treatment. — *Neuralgia.* — Facial Neuralgia. — *Tic-douloureux.* — Otalgia and Odontalgia. — Neuralgia of Cervical Nerves. — Of Intercostal Nerves and Infra-mammary Pain. — Pains in the Loins. — Neuralgic or Hysterical Affections of Joints. — Headaches and Head-pains. — Rule for treating Neuralgic Affections with Electricity. — The "Painful Points" of Dr. Valleix. — Anatomy of Nerves in the *Facial Neuralgic Region*, and *illustrated.* — Anatomy of Nerves in the *Occipito-cervical Neuralgic Region*, and *illustrated.* — The Pneumogastric Nerve and the Eighth Pair *illustrated.* — Anatomy of Nerves in the *Cervico-brachial Neuralgic Region*, and *illustrated by several engravings.* — Anatomy of Nerves in the *Dorso-intercostal Region.* — Anatomy of Nerves in the *Lumbo-sacral* and *Abdominal Region*, *illustrated.* — Anatomy of Nerves in the *Sciatico-femoral Neuralgia Region*, and *illustrated* by several engravings; thus giving the engravings and minute explanation of all the surface and superficial Nerves in the Human Organism that are liable to Neuralgia or Palsy, and are to be reached by the Electrodes. . . . . 472

## CHAPTER VII.

*Anæsthesia.* — Diminished Nerve Action and Paralysis. — General Palsy. — Muscles of the Body and Limbs, anterior view *illustrated.* — Muscles of the Body and Limbs, posterior view *illustrated.* — Skeleton, Anterior View *illustrated.* — *Skeleton*, Posterior View *illustrated.* — Paralysis. — Views of Marshall Hall, Todd, and others. — Electro-muscular Diagnosis. — Hemiplegia. — Early and late Rigidity, or Tonic Muscular Contractions from Brain Lesions. — Cases to illustrate. — The Electric Test. — Cases to illustrate. — Paraplegia. — Catalepsy. — *Local Palsy.* — Anæsthesia. — Traumatic Paralysis. — Cases to illustrate. — Facial Palsy, two Classes. — True Facial Palsy, and Simple Paralysis of the Facial Nerve. — *Lead Palsy.* — Muscles on the Back of Forearm and Hand, *illustrated* by Engravings. — Rheumatic Palsy. — Muscles of the Hip and Thigh, and of the Front of the Leg, *illustrated* by Engravings. — "Spasmo-paralysis" in Childhood. Muscles on the Back of the Thigh, *illustrated.* — Wasting Palsy. — Hysterical Paralysis. — Aphonia, or Loss of Voice. — Treatment by Electricity. . . . . 653

## CHAPTER VIII.

*Spastic Diseases.* — Cramps. — Spasms. — Convulsions. — Views of Dr. Marshall Hall on the Spinal System. — His Trials with Electric Currents on Spinal Diseases. — Trachelismus. — Laryngismus Stridulus. — Physiology, Pathology, and Electro-physiology as Means of Diagnosis. — Researches of Wm. Flourens. — Of Professor Weber. — Spasm, Paralysis, and Spasmo-paralysis. — Epilepsy. — Views of Drs. Todd, Hall, and Brown. — Sequard on Epilepsy. — Asphyxia. —

Tonic and Clonic Convulsions. — Exhaustion of Nerve Power. — Asthma and Angina Pectoris. — Chorea, (St. Vitus's Dance.) — Hysterical Convulsions. — Cramps, Hickups, and Tremblings. — Tetanus and Agitans. — Effects of Electric Currents as a Remedy. — Chills and Fever. — "Dumb Ague," Intermitting Fever. — Diseases of *Nervous Debility*. — Treatment by Electricity. . . . . 860

## CHAPTER IX.

*Midwifery*. — *Abdominal Viscera*. — *Secretions*. — Effects of the Electrical Current on the Uterus. — Professor Simpson's Views. — *Nerves of the Uterus demonstrated*. — It is Reflex Action that affects the Womb. — Electro-physiology repudiates *direct* Excitation from Continuity or Contiguity. — Stimuli directed to the Mammary Nerves. — To the Intercostal Nerves. — To the Pneumogastric Nerves. — To the Spinal or Abdominal Nerves. — Prolapsus Uteri. — Introversion and Retroversion. — Amenorrhœa and Dismenorrhœa. — Electricity the only *true* Emmenagogue. — Chlorosis. . . . . 921

## CHAPTER X.

*Nervous Affections of Thorax and Abdomen*. — Heart Derangements and Diseases. — Narcotism of the Heart by Tobacco. — Asthma. — Consumption. — Tuberculosis. — Scrofulosis. — Nervous Dyspepsia. — Obstructed Liver. — Paralysis of the Hepatic Plexus. — Bowels. — Atonic Constipation. — Ilius. — Chronic Diarrhœa. — Cholera. . . . . 945

## CHAPTER XI.

*Feigned Nervous Affections*. — *Sea-sickness*. — Cold Feet and Hands. — *Alcohol*. — *Tobacco*. — *Sham Doctors*. . . . . 979

## CHAPTER XII.

*Electricity in Surgery*. — Electric Currents cannot produce complete and simple Anæsthesia. — Nervous Affections of the Eye. — Of Eye Muscles. — Black Spots. — Artificial Pupil. — Nervous Affections of the Ear. — Indolent Ulcers. — Electric Moxa. — Electro-puncture for Aneurism. — Acu-puncture. — Un-united Fracture of Bone. — Electric Cautery. — Surgical Dentistry. — Faradaic Process in Tooth-extracting. — Spinal Diseases. — "*White Swellings*." — Hydrocele. — Spermatorrhœa. — Strictures in the Urethra. — Neuralgia and Palsy of Bladder. — Palsy of Rectum. — Hydatids. — Electro-Cautery. . . . . 994

# LIST OF ENGRAVINGS.


| FIGURE | | PAGE |
|---|---|---|
| 1. | Thermo-Cube — a most delicate test for heat. | 30 |
| 2. | Atmospheric Hydrometer. | 53 |
| 3. | Galvani's Frog. | 95 |
| 4. | View of Elementary Muscle Fibres — highly magnified. | 131 |
| 5. | View of Nerve Fibrils magnified — effects of electric currents. | 138 |
| 6. | View of the Electric Torpedo — fish of the American coast. | 162 |
| 7. | View of the Electric Eel — fish of American fresh waters. | 164 |
| 8. | View of Prepared Frog's Legs — for illustration of nerve action. | 180 |
| 9. | View of the *Poles* of a Galvanometer — for electro-physiological testing. | 182 |
| 10. | View of Same. | 182 |
| 11. | View of a Muscle lying upon the pole-guards for testing. | 183 |
| 12. | View of the Galvano-scopic Frog — a most delicate test. | 187 |
| 13. | View of the Galvanometer — for testing currents of electricity. | 188 |
| 14. | Diagram illustrating the Polarity of Nerve-molecules. | 189 |
| 15. | Diagram of Same. | 190 |
| 16. | Diagram of Same. | 191 |
| 17. | Diagram illustrating Nerve-molecules in action and at rest. | 191 |
| 18. | Diagram illustrating the Nerve-current Direction. | 192 |
| 19. | Diagram of Same. | 195 |
| 20. | Diagram illustrating the Secondary Electro-Tonic State. | 195 |
| 21. | View of the Brain — showing its base and the medulla oblongata. | 233 |
| 22. | View of a Piece of the Spinal Cord and its Nerve-roots. | 242 |
| 23. | View of the Spinal Column laid open. | 242 |
| 24. | View of the Brain Convolutions and Spinal Nerves to the Cauda Equina. | 243 |
| 25. | View of the Posterior Roots of the Spinal Nerves. | 243 |
| 26. | View of the Ear. | 252 |
| 27. | View of the Great Ganglionic System of Nerves. | 265 |
| 28. | View of the *Regions* of the Human Body. | 269 |
| 29. | View of the Muscle Fibres — magnified six hundred diameters. | 288 |
| 30. | View of the Pneumogastric Nerve. | 291 |
| 31. | View of the Muscles of the Face and Neck. | 293 |
| 32. | View of the Muscles of the Back. | 296 |
| 33. | View of the Muscles of the Back — deep layer. | 300 |
| 34. | View of the Muscles of the Front Side of the Body. | 302 |
| 35. | Lateral View of the Muscles of the Body. | 303 |
| 36. | View of the Electric Machine for Static Electricity. | 311 |
| 37. | View of the Leyden Jar. | 312 |
| 38. | View of the Dischargers. | 313 |
| 39. | View of the Insulating Stool. | 314 |
| 40. | View of the Voltaic Pile. | 318 |
| 41. | View of the Berzelius Battery. | 322 |

FIGURE PAGE
42. View of the Daniell Battery — a series in connection. . . . . 324
43. View of the Grove Battery — twelve in connection. . . . . 325
44. View of the Grenet French Battery for Heat and Electro-Cautery. . . . . 327
45. View of the Smee Battery — a single cell, (element.) . . . . . 329
46. View of the Humboldt Battery. . . . . 329
47. View of the Pulvermacher *Chain-battery*. . . . . 330
48. View of the Astatic Needle — for testing delicate electric currents. . . . 347
49. View of the Electro-Magnetic Helix with Clock-work. . . . . 351
50. View of the Electro-Magnetic Helix with its Battery Cell, (old style.) . . 352
51. View of the Electro-Magnetic Apparatus with its Vibrating Electrotome. . 354
52. View of the Electro-Magnet. . . . . 357
53. View of the Electro-Magnetic Portable Apparatus in Box. . . . . 357
54. View of the Chester Battery. . . . . 360
55. View of the Electro-Magnetic *Kidder* Apparatus. . . . . 361
56. View of the Electrotome (Vibrator) — a new adjustment. . . . . 362
57. Diagram to illustrate the Kidder Apparatus. . . . . 363
58. Diagram to illustrate the Construction of a good Helix. . . . . 365
59. Diagram to illustrate Same. . . . . 366
60. View of Duchenne's Electro-Medical Apparatus, and the Method of holding, *in one hand*, the two *Exciters* (Electrodes) as he directs for practising "*Faradaization.*" . . . . . 368
61. View of Duchenne's *Exciters*. . . . . 369
62. View of Rhumkorff's double-coil powerful Apparatus. . . . . 370
63. View of Hall's "*Constant Battery*" for Medical Purposes. . . . . 371
64. View of Hall's "*Petit*" Battery — for the carriage of practitioners. . . . 374
65. View of the *Magneto*-Electric Machine in Box. . . . . 377
66. View of the Compound *Magneto*-Electric Machine. . . . . 378
67. View of the Æsthesiometer. . . . . 382
68. View of the Key-board, or Manipulator, of the Primary Current. . . . . 384
69. View of the Large *Wire Brush Electrode*. . . . . 385
70. View of the Vaginal Glass Electrode. . . . . 385
71. View of a long-handled and large Sponge Electrode. . . . . 385
72. View of Electrode for small or deep Surface. . . . . 385
73. View of Electrode of Gutta-percha and flexible for Uterus or Rectum. . . 385
74. View of Electrode of Metal. . . . . 385
75. View of Electrode for the Ear. (For smaller ones see Fig. 104.) . . . . 386
76. View of Electrode for electrifying the Throat and Fauces. . . . . 386
77. View of Electrode for electrifying the Tongue. . . . . 386
78. View of Electrode for electrifying Hands — half insulated. . . . . 386
79. View of Electrodes of Metal — hollow, for receiving sponges. . . . . 386
80. View of Electrode of Glass for the Eye. . . . . 386
81. View of Electrode with large Metal Ball covered with Wash-leather. . . 386
82. View of Electrode of Glass with large Sponge. . . . . 386
83. View of Duchenne's "Exciters," (Electrodes.) . . . . . 386
84. View of my *Swivel-Electrode* — for passing inside the dress of ladies, for the back, stomach, or bowels. . . . . 387
85. View of Simpson's Galvanic Intra-uterine Electrode. . . . . 387
86. View of my Spoon-sponge Electrode and Insulated Conductors. . . . . 387
87. View of my plan for speedy contact without screw. . . . . 387
88. View of *a little Wire Brush Electrode for Faradaization*. . . . . 387
89. View of Garratt's Spoon-Electrode — the best for general purposes. . . . 387
90. View of the Electrode Handle for Electro-Cauterization. . . . . 388

| FIGURE | | PAGE |
|---|---|---|
| 91. | View of the Double-tip, (platinum and porcelain,) for Electric *Heat*. | 388 |
| 92. | View of the Double-tip for Electro-Cautery in deep Parts. | 388 |
| 93. | View of Same. | 388 |
| 94. | View of Same. | 388 |
| 95. | View of the Double-tip for Dentists' Use. | 388 |
| 96. | View of Same. | 388 |
| 97. | View of Foot-board, or Current-breaker, for Dentists' Use. | 388 |
| 98. | View of Electrode Slipper. | 388 |
| 99. | View of Electrode, (Female Catheter *insulated*.) | 389 |
| 100. | View of Electrode, (Male Catheter, *insulated*.) | 389 |
| 101. | View of Electrode, insulated, flexible, and gold-tip, for the Eustachian Tube. | 389 |
| 102. | View of Electrode for electrifying the *chordæ vocales*. | 389 |
| 103. | View of the Æsthesiometer — for testing lost sensibility. | 389 |
| 104. | View of my Ear Electrode — of ivory, silver wire, and sponge. | 390 |
| 105. | View of my Ear Electrode — insulated and flexible. | 390 |
| 106. | View of my Eye Electrode with fine Sponge-tip. | 390 |
| 107. | View of Same. | 390 |
| 108. | View of Same. | 390 |
| 109. | View of my Electrode (Pea-shaped Sponge) — for electrifying a nerve-trunk. | 390 |
| 110. | View of my Large Cupping-glasses, Oval, Oblong, and other shaped. | 456 |
| 111. | View of Same. | 456 |
| 112. | View of Same. | 456 |
| 113. | View of the Facial Nerves. | 543 |
| 114. | View of the Tri-facial Nerves, or Fifth Pair. | 546 |
| 115. | View of the Surface Nerves — Cervico-brachial Region. | 554 |
| 116. | View of the Brachial Plexus and Arm Nerves. | 557 |
| 117. | View of the Nerves, Arteries, and Veins at bend of Elbow. | 558 |
| 118. | View of the Nerves on the *Front* of the Fore-arm. | 559 |
| 119. | View of the Nerves on the *Back* of the Fore-arm and Hand. | 560 |
| 120. | View of the Nerves in the Lumbar Region and Ischiatic Plexuses. | 567 |
| 121. | View of the Femero-Crural Nerves and Branches. | 572 |
| 122. | View of the Great Sciatic Nerve and Region. | 574 |
| 123. | View of the Popliteal Nerve and Region. | 575 |
| 124. | View of the Nerves of the Posterior Tibial. | 576 |
| 125. | View of the Nerves of the Bottom of the Foot. | 577 |
| 126. | View of the Anterior Tibial Nerve. | 578 |
| 127. | View of a Scrofulous-rheumatic Hand — to illustrate. | 630 |
| 128. | Anterior View of the Muscles of the Body and Limbs. | 657 |
| 129. | Posterior View of Same. | 658 |
| 130. | View of the Muscles on the Front of the Fore-arm. | 751 |
| 131. | View of the Arm Muscles illustrating "*Essential Palsy of Childhood*." | 787 |
| 132. | View of the Deep-seated Muscles of the Hip Joint. | 808 |
| 133. | View of the Muscles on the Back of the Thigh. | 809 |
| 134. | View of the Muscles on the Front of the Thigh. | 810 |
| 135. | View of the Muscles on the Front of the Leg. | 811 |
| 136. | View of the Muscles of the Hand showing the *Lumbricales*. | 812 |
| 137. | View of the Muscles on the Back of the Fore-arm, (Extensors.) | 829 |
| 138. | View of the Muscles and Tendons on the Back of the Hand. | 831 |

# ELECTRO-THERAPEUTICS.

## CHAPTER I.

### NATURAL ELECTRICITY.

In the physical sciences it is now assumed that all bodies, animate and inanimate, contain a subtile influence which Philosophers have from time to time designated as *Natural Electricity*. This influence has two distinct characters. It is divided into these two parts by natural, as well as by artificial disturbances; yet is it subtile, invisible, and imponderable. These divisions are now familiarly known as *positive* and *negative* electricities, whose tendency is to coalesce, and form that equilibrium which we call natural electricity. The particles or molecules of the one kind, always attract those of the other, or opposite kind. The particles of the same kind, be they positive or negative, always repel their fellows of the same order. Although ever tending to obtain a counterpoise for a rest, yet as easily and perpetually are these two electricities unbalanced, even so sure as our revolving globe receives her accession, duration, and declination of solar rays. So also, whatever disturbs any molecule of matter, fluid or solid, as heat, friction, or chemical action, as also magnetism and vitality, liberates *active electricity*. The relative greatness of quantity and of tension of the given electricity, varies even to the greatest extreme, according to its source; but its nature is always one and the same.

It is presumed that every intelligent practitioner of medicine, in these days, understands the fundamental Laws of Electricity; but the author makes here a free but easy rehearsal of so much of those *laws* and *conditions*, to which in its respective forms Electricity is obedient while acting upon, or traversing through, the different living tissues of the human organism, as will prove a sufficient *vade mecum*, in its department, for ready reference to the working practitioner. Certainly no conscientious and high-minded person would be willing to attempt to employ this powerful agent in any form on the human body, *actively*, as a remedy, and much less as a trifling experiment, without first being familiar at least with the outlines of its sources, its properties, its actions, and its results.

## *Sources of Electricity.*

There are usually acknowledged *three principal sources* of appreciable Electricity; namely, heat, mechanical friction, and chemical action. While inanimate bodies are at rest, there is no appreciable electricity to be found. The positive and negative exist in them in such proportions, that, although they do not destroy each other, their effect is counterbalanced, and their very existence is masked. Under the same distance and circumstance, the attractive power of the one is equal to the repulsive power of the other. This natural rest of electricity must therefore be disturbed, in order to produce any *appreciable* existence or action.

The earliest mention of electricity is supposed to have been by the Ionian philosopher, Thales of Miletus, who discovered that if a smooth piece of amber was rubbed with a dry cloth it attracted various light bodies that were placed near it. Although he was reckoned as one of the seven wise men of Greece, it is also recorded of him, that from this phenomenon he supposed that amber possessed a soul, and was thus nourished by the attracted bodies. This was at an early day, however, for he died in the ninety-sixth year of his age, about five hundred and forty-eight years before the Christian era. Pliny the elder also

speaks of a hard, violet, or deep-red colored stone, which, when heated in the sun, and then rubbed with the fingers, would attract small light bodies. We now know that when a piece of amber, wax, or glass is rubbed with a dry cloth or fur, it acquires the property of attracting light bodies, as pith balls, or bits of paper, because the friction has decomposed the natural electricity of the amber, or wax, so that it has become "*minus*," as Dr. Franklin would say, or resinous and *negative*, as it is now more familiarly termed; i. e., the negative electricity is thus accumulated in a state of rest in the rubbed, non-conducting body; so that if now it is approached by any light body, a law of electricity is observed, and the bit of paper, for instance, is attracted to the amber, and that neutralizes a given portion of its single electricity, but still adheres to it. If the paper were larger, so as to neutralize all the negative electricity of the amber, it would then instantly leave by repulsion. This kind is therefore termed "*frictional electricity*."

A quiet and simple elevation of temperature, is also alone sufficient to render a body electrical which was not so before. This is termed *heat*, or *thermo-electricity*, to distinguish it from *pyro-electricity*, which was discovered first in the tourmaline and then afterwards in other crystals and precious stones; also to designate it from *hydro-electricity*, which was a term early applied to voltaic electricity, and which is the same as galvanism.

The third great source of electricity, then, is from chemical action; and this is termed *dynamic* or *voltaic electricity*, — so called after its distinguished discoverer, and also because it is in currents or motion. It is, as just said, also termed *galvanism*. But there are also two other important sources of electricity; and these are magnetism, and the animal body. These will severally be considered under their respective heads; but we must observe that there is another phase of electricity which we should notice, and that is, first, *electricity at rest*, as accumulated in or on a non-conductor, and hence termed "static electricity," and second, *electricity in motion*, as from chemical decomposition, &c., and hence termed "dynamic electricity."

## *Nature of Electricity.*

It is important, before we go further, for us to form an *idea* of the properties of electricity, or, in other words, of what electricity *is;* at least, to be reminded of the opinions that have been formed on this subject. The knowledge of these theories, as has been remarked, is absolutely necessary for us, even were it only to make us familiar with the established expressions employed by writers on this subject. But all this will be more fully and naturally explained, in connection with the history of the development of this branch of science. Here then, we will only stop to mention certain prominent opinions.

Dr. Benjamin Franklin's theory consisted in admitting but one single imponderable *electric fluid*, very subtile, and that all the particles of which mutually repel each other; that each body has a determinate capacity for this fluid; that a body is in a natural electric state when it contains as much as it ought naturally to have. He held that to electrize a body vitreously, is to give it more electricity than it naturally contains; and when so conditioned, the body is in the *positive* electric state. To electrize a body resinously, is simply to deprive that body of a portion of its natural electricity, and then it is in a *negative* electric state. So that Franklin's theory gave rise to the terms *positive* and *negative* electricity the world over. But his theory of simple *plus* and *minus*, just as he gave it, cannot, in the present state of the sciences, be admitted.

We now regard the two electricities, the vitreous and the resinous, as excessively subtile and imponderable fluids or influences, each of which orders is composed of particles that naturally repel each other, while the particles of the one order as naturally attract those of the other order; that these different influences or fluids are able to travel in and through conducting bodies; yet as their fellow-particles of the given order tend to repel each other mutually, they therefore, when on insulating bodies, arrange themselves on the surface of these, and remain, because they meet the dry air, which being to them an insulator, they can go no farther. Why a given article, as amber or glass,

is a non-conductor, or why these two fluids are so restrained in their movements, until they accumulate to a given degree, we cannot further explain, than to attribute this to their being held by the peculiar particles of these bodies; but that when these two influences — positive and negative — do unite by virtue of their mutual attractions, they then become *one* natural electricity, which is neutral, the relative action and influence of which is insensible. Such are the more modern and commonly received views, which are indeed based upon the celebrated "*Symmer's two-fluid theory.*"

M. De la Rive, however, says, "We may for the present say it is very probable that Electricity, instead of consisting of one, or of two special fluids, *sui generis*, is nothing more than the result of a particular modification in the state of bodies, which modification probably depends on the mutual action exercised on each other by the ponderable particles of matter, and the subtile fluid that surrounds them on every side."

## *Thermo-Electricity.*

From the earliest times philosophers observed that *heat* facilitated the development of electricity, particularly if it was attended with friction, and on insulating bodies. M. Becquerel lays down as fundamental, that the propagation of heat, at least in a metal, is always attended with a liberation of electricity, and that the current is from the heated end towards the colder end of the bar. Thermo-electric currents are *not instantaneous*, like those of induction, and for that reason thermo-electricity is not calculated for the production of electric currents, except in particular cases, as where we are more concerned in *studying the effects* of dynamic electricity, than in producing effects, or determining the laws of its propagation. The *thermo-electric pile* of Nobili, formed at first of only six dry pairs of bismuth and antimony, has been greatly multiplied and improved, so that it now constitutes one of the most sensitive and delicate means known for appreciating differences of temperature. M. Melloni improved this by composing a pile of some fifty small and slender

bars of bismuth and antimony of about two inches in length, so soldered together alternately and folded back and forth upon itself, as to form a very small compact cube, or block, by means of insulating wax, or shellac, for filling the vacancies between the bars, which must touch only at their solderings.

The two extreme ends of this sort of folded chain, the one of bismuth and the other of antimony, which are the poles of the pile, connect, by two short bits of ordinary insulated copper conducting wire, with the two extremities of a multiplier. The two studs pass through a piece of ivory, or glass, fixed upon a metal ring, which receives the thermo-electric block, and may be furnished with a pivot, or a hinge, by means of a piece attached, and so allow the axis of the pile to be placed hanging in any direction. The face of this instrument, that we now wish to be kept at an *ambient* temperature, must be covered with a finely-polished metal shield, which so envelops it as not to touch it; while care must be taken to blacken the terminal faces of the pile, which is to be uncovered and turned directly facing the source of the heat, or cold, that is to be tested. The nice sensibility of this apparatus, small and exceedingly simple as it is, we learn from M. De la Rive, is such, that if the uncovered face of this little pile is turned towards a person who stands at a distance of even twenty-five feet, the deviation of the needle of the multiplier *detects* the emanation of the radiant heat of that person, and shows the evidence to all who behold! By this marvellously delicate instrument, MM. Nobili and Melloni were enabled to discover the presence of heat even in *insects* — in phosphorescent bodies, and under many circumstances where it could not be detected by any other known means.

Fig. 1.

M. Becquerel has taught us to make use of thermo-electricity for the measurement of the temperature of the different tissues of the human body, by preparing mixed metallic needles of a diameter of less than a twentieth of an inch, which are used simply by introducing them as we do acu-puncture needles. Then, if we compare thoroughly, yet very carefully, all the phenomena in which heat and electricity are concerned together, we

every where discover molecular influence becoming very manifest; *the passage of the artificial electric current, by increasing the polarity of the atoms, exalts their velocity of rotation, and this again increases their individual electric polarity.* The idea thus put forth by M. De la Rive, and Dr. A. Smee, that atoms have an electric polarity, which they owe to a more or less rapid motion by rotation, leads us to think that if this facility for actual increase of rotation is truly augmented also by moderate heat, and at the same time it exalts their electric polarity, we may, in some measure, and I think in a very satisfactory manner, account for what takes place in living bodies, as electro-calorific phenomena, since this applies mostly to *moist* tissues or fluids.

### *Static Electricity.*

It is true that natural electricity is at rest, because it is neutral; but this is not what is meant by static electricity, although it also refers to an electricity at rest. But where the natural electricity of bodies has been decomposed, as by friction, heat, or decomposition, then there is a separation of the positive and negative, the one occupying a given locality, and the other another, in a state of accumulation and rest, as on insulated and non-conducting bodies. This state is also called *electric tension.* Hence, when the electricity that is produced by the friction *electrical machine* is spoken of, in connection with medical practice, we always designate it as *static electricity.* This form of electricity, above all other forms, exercises the most remarkably attractive and repulsive powers, even at a distance. But the energy of these properties are in proportion to the tension and distance. The neutralization of these two electricities is usually instantaneous and by a spark or shock. The neutralization can take place slowly and imperceptibly, as through imperfect conductors. The *quantity* of frictional or static electricity is always relatively small, but it possesses the highest degree of *tension.* For this reason it is easy to draw very brilliant sparks from the electrical machine, while large and powerful series of galvanic batteries, which furnish an enormous quantity of electricity, (but

of less relative tension,) will produce only the least spark. Now, if these two kinds of electricities, i. e., positive and negative, be constantly renewed, there will likewise be a continuous neutralization, either through the air as a fine succession of sparks, or through a conductor in contact. The essential difference between a *discharge* of electricity, and a *current* of electricity, as they relate to physiology and therapeutics, will be plainly delineated in this work. I will only mention here, that a discharge or shock, although it produces a number of other powerful effects, has almost no chemical effect and no influence on the magnetic needle, whilst all *currents* of electricity are able to accomplish both.

We find that we can produce electricity instantly and constantly; but the *accumulation* of electricity is a matter of time. And here I must remind you of an electric law that is not so known, or else is more generally forgotten; and that is, that one of the electricities by friction is never liberated without the other or opposite electricity being equally so, and that in the same proportion. I mention this as a particular reminder, because a provision must for this reason be always made for the escape (as for instance to the earth) of the electricity we do not want, *in order* to obtain freely and largely that other kind which we do want. This law, first laid down by M. Wilke, applies also to other forms of electricity, but all the more distinctively in this, where one only of the electricities is collected, as for instance when highly charging the Leyden jars. True, Faraday caused two bands of flannel to be rubbed against each other crosswise, and thus both were rendered negative. But this is an apparent exception, although it can be explained.

Finally, we are taught that the kind of electricity that is developed upon a body does not depend solely upon the nature of this body, but likewise upon that of the substance with which it is acted upon, or rubbed, as one electricity is never developed without its opposite; and either of these may prefer to accumulate on the one or other body. There is *not*, therefore, an identity between the electricity that glass acquires by friction, and which we call vitreous, and that which wax acquires, and which

is termed resinous, since on each of these bodies, although electrized in the same manner as exactly as possible, the effect of the former is *repulsive*, and that of the latter is *attractive*. As experiments teach us that all bodies in nature upon being rubbed acquire one or the other of these two electricities, the following law is deduced: —

1. That there is an attraction between two bodies electrized, the one as by glass, the other as by wax.

2. That there is *attraction* between an electrized body and a body that is not so.

3. That there is a *repulsion* between two bodies that are electrized by the *same* source of electricity, and consequently if possessed of the same kind of electricity, whether that be positive or negative.

### *Dynamic Electricity.*

While the neutralization of an appreciable electricity is being brought about, either through the air as a spark, or invisibly through a conductor, it is said to be in a *dynamic* condition, for it is moving. This term is therefore applied to all electricity *in motion*, as where the positive and the negative are supposed to be travelling towards each other through a conductor, and constituting a current, and at the same time neutralizing each other. This denomination includes therefore all electricities that are not included in the denomination of *static*, as before mentioned; but we must here except natural electricity.

The dynamic state of a given electricity may be only *instantaneous*, or it may be more or less *continuous*. It is instantaneous when there is an *electric discharge*, and consequent neutralization of the accumulation; or it is continuous where there is a source of constantly renewing supply, as through a closed conductor of a battery, and this is termed the continuous dynamic condition, or *electric current;* and hence we say that the conductors, and whatever body is included between the poles of those conductors of a battery, are *traversed* by a current. And here lies the gist of the whole matter: the works that can be accomplished between these two tips of wires, called *poles*,

already telegraphing nations with a harmony of intelligence, besides performing every day a thousand other useful works, must also be brought to the aid of our enfeebled bodies, or deranged nervo-telegraph systems, to vivify, to restore communication, to clear them of their debris, and enable them again to regulate their more normal and constantly-renewing supplies. We find also the general principle, that every disturbance impressed upon a body — and this peculiarly applies to the living human body — from which arises any change, or even the slightest disturbance in the state of its molecular equilibrium in any department, is strictly accompanied by a like production of electricity, which is manifested more or less according to the physical and chemical condition of the body so disturbed.

To sum up, then, we are able to show a rigorous principle that is now fairly demonstrated, viz., that not only friction and heat, but also *every sort* of mechanical and chemical action which disturbs the minutest particles of the human organism, becomes the producer of electricity in that body; which, in the living body, we see manifested through the nervous media — first, for healthy function; second, for diseased action. In health, and within certain bounds, electricity does not accumulate in the body, nor yet does it greatly diminish, as occurs in disease, because the two electricities for the most part tend to recompose to a balance, and so become quiet; yet at the same time the same process is continually succeeding. Indeed, we are enabled to prove by direct and conclusive test, as by the aid of a sensitive galvanometer-multiplier, that every minutest chemical action gives rise to an electric current. This action may be that of a liquid upon a solid, or upon two solids, or of two liquids upon each other, or of a gas in connection with any of these, under certain conditions, or it may be that peculiar action which characterizes all the phenomena of slow or rapid combustion. But all this will be more clearly illustrated in Electro-physiology.

## ATMOSPHERIC ELECTRICITY.

A little over one hundred years ago Dr. Benjamin Franklin, the illustrious native of Boston, Massachusetts, first of all obtained the proof that the lightning and thunder of the clouds, are due to electricity alone, and are indeed the same as electricity artificially produced by means of friction accumulated and discharged by the Leyden jar. True, this was strongly conjectured in all those years, as indeed it had been by the Romans for centuries before, but no one could prove it. In physics, it is experiment and demonstration, first and alone, that can decide. Therefore our Franklin resolved to send into that region of thunder, and bring to earth *a spark of evidence*, which he actually accomplished in 1752, by means of his famous kite. And this proved a satisfactory answer. By it the learned world was truly electrified. New interest every where burst forth in this field of natural science. At once, from the city of Mexico to Moscow and St. Petersburg, kites were flying in the service of philosophy. Other effective means were also soon devised to witness this then new and extremely interesting phenomenon. M. de Romas, in June, 1753, raised his kite for this purpose, with a very fine copper wire inlaid through the whole length of the kite-string; and thus he obtained most wonderful effects. It is said that he drew from the kite, which was thrust high into the midst of the shower clouds, sparks or streaks of lightning from eight to ten feet long, and one inch in diameter. Notwithstanding his precaution, in using large glass insulators, with which to hold the kite-string while experimenting, he was knocked down by a shock, but was not killed. Professor Richmann, of St. Petersburg, however, erected a tall iron rod for the same purpose, and during a thunder storm it led a bolt of lightning into his house. The rod not being well connected with the ground, or perhaps not at all, as he stooped down to watch the experiment at the bottom of the rod, and near the

floor, he was struck in his head and killed instantly. Lightning and thunder, then, is but a simple discharge of electricity, only on a large and magnificent scale.

### *Clouds.*

We may notice, without the weather being decidedly stormy, that the very presence, in the otherwise serene atmosphere, of a small or thin, fine cloud, or of the fall of a few drops of rain, or a few flakes of snow, *is sufficient to modify* the normal state of electricity in the air. But this is far from possessing the importance that results from the existence of a storm, a dense fog, or thunder and lightning, with wind, rain, hail, or snow.

The mere formation of a single cloud, or of the slightest fog, is accompanied with a sensible disturbance of the electric state of that stratum of air in which this formation takes place. The aqueous vapor with which the atmosphere is always more or less saturated, being usually invisible, becomes in the clouds and fogs visible; and we know that their globules are so many small spherical balloons, in which a small capsule or pellicle of water serves as an envelope to the interior air, which is polarized. We have only to place an electroscope in the middle of a cloud, or fog, when driven by the wind, and we see how greatly the divergence of the needle varies with the passage of the successive flakes of denser portions of the fog or cloud.

Now, to understand in some degree those wonderful electric phenomena of clouds over and about us, and which are so full of meaning, it is well, and indeed necessary, to be more familiar with the individualities of each of the globules of which they are composed. But this must not be entered upon here. I will only remind you, that the globules themselves are grouped by small flakes, which have their limits and their spheres of action, much like the globules themselves; the small flakes, by grouping, constitute the large flakes; the latter group and form *Mamillæ;* a certain number of these again, by their reunion, form a *Cloudlet;* and the cloudlets marshal by a law into given definite clouds; and these again, grouping as so many individual and definite

clouds, thus result in a *Cumulus;* and several cumuli organize into a *Nimbus.*

Then, again, the clouds themselves, if we except the invisible clouds, are distinguished as three grand species or kinds: the *Cirri*, which have the appearance of loose filaments, and fly the highest; the *Cumuli*, which are less elevated, have a rounded appearance, and form the large clouds which we see usually accumulated or formed at the horizon, and which we fancy so resemble the gorgeous sight of distant mountains when covered with snow and sunshine; or as if the looming and approximating of the very land of Beulah. The next are the *Stratose* clouds, which are horizontal and parallel stripes, or bands, forming at sunset, and disappearing again between break of day and sunrise. We observe that when the *Cumuli* are piled up, and become quite dense, they then pass into the compound state of *Cumulo-stratus*, which themselves shortly after pass into the state of *Nimbi*, or true rain clouds. These latter are distinguished by their uniform gray tint, with fine fringe edges; this, however, soon passes into the uniform, undefinable, and extensive *Storm Clouds*, which are peculiar for being without visible edges.

*Thunder clouds* are usually formed during the heat of summer days, from the occurrence of a rapid condensation of the vapor with which the atmosphere is then saturated. When this watery vapor, or evaporation from the earth's surface, reaches an elevation where the condensing power of cold (magnetism?) is sufficient to overcome the repulsive force of the electricity that attends the vapor, then thunder clouds are speedily formed, and the electricity, like latent heat, becomes sensible in the condensed vapor of that cloud. As the earth is the great reservoir of electricity, so is evaporation the principal and perpetual agent in conveying off the earth's surface electricity so abundantly to and throughout the upper strata of the atmosphere. The evaporation of the earth's moistures is too extensive to be computed and comprehended, and yet it is this mighty force, that, particle by particle, carries off and up to the sky such prodigious quantities of electricity, which particles themselves are rendered all the more volatile by the self-repellent effects of the minute po-

larized electricity which they severally contain. As these minute globular particles increase in density and extent, the tension of their free electricity becomes greater, until this speedily reaches such a degree as to overcome the resistance of the non-conducting air, when a discharge of lightning takes place, either to the earth or to some other cloud less charged.

Thunder clouds are often negative in regard to each other, as also in regard to the earth; in that case the lightning is seen to leap from one to the other, until the equilibrium is nearly or quite restored between them. But it is the new and *isolated* thunder clouds, those which form so rapidly from vapor condensed by the violent meeting of very warm and very cold currents of air, that present the highest degree of electric excitement, and exhibit the most terrific electric phenomena. As the thunder storm and shower clouds now approach, the flaky portions of these clouds are observed to be in the greatest commotion by a whirling and flying of various detached portions, and a scudding of other fragments to other denser portions, as if to find an adjustment — the whole having a dismal, dark, or black and threatening aspect, which are instantly and fearfully augmenting; and then comes the blazing of frequent discharges of lightning, followed by, or almost simultaneous with, crashing peals of terrific thunder, and that with torrents of rain. These thunder clouds, then, may be regarded as a huge panorama of electric batteries suspended in the sky and insulated merely by the surrounding air.

## *Meteorology.*

Meteorology, medical geography, and topography embrace a wide range of study, as they relate, on the one hand, to the sources and nature of disease, and, on the other, to the subjects of hygiene and treatment. To this end we may receive instruction from the thermometer, barometer, hydrometer, electrometer, the measure and record of amount of direct solar light, observations of winds, moonlight, &c.; as also from the geographical position of a given locality, and the physical aspect of the surrounding country; from the geological formations, its flora, its fauna, the pre-

vailing and occasional characteristics of the climate as a whole, *in conjunction with the nature and phase of the prevailing acute and chronic maladies.* Either of these classes of observations alone is comparatively worthless. The cause and result, the result and cause, must be repeatedly canvassed until familiarly known. In connection we are to inquire, also, how far the habits and modes of life, the water and other fluids, as well as the food the people use, or the medical treatment they receive, may influence the results. But to a work like this belongs rather that department of the phenomena that *result mainly from electrical influences.*

When the sky is gray or hazy, and the direct rays of the sun are dim, *i. e.*, more or less *for a long period*, during very warm weather, together with a moist atmosphere and evidences of weak, *nil*, or negative electricity, we observe that the returns of health are not so favorable. The same is true, at any season of the year, after *a long spell of high winds*, protracted drought, or a succession of violent storms, — either of which is usually attended with *superabundant* positive electricity of high tension; and the prevailing affections immediately observed are influenza, lung fever, inflammatory rheumatism, and other sthenic diseases. A large amount of *direct* solar rays of light is as essential to the health and vigor of the human family as it is to the vegetable creation. On those days when negative electricity prevails, there is less light from direct solar rays. That is, there is less direct sunlight through such days than on clear and serene days, when the electricity of the atmosphere, both in the upper and lower strata, is usually positive. *Negative* electricity, then, is coincident with still, smoky, humid, dirty, drizzly weather; *positive* electricity with the cool, cold, clear, and frosty, or the windy, real rainy, hot, and dry weather.

During the summer and autumn of 1864, the temperature of our New England sky was high and dry, so that for more than two hundred days the atmospheric electricity marked very uniformly positive, and frequently active, with now and then various degrees of tension. We suffered somewhat from apprehension in regard to the exhaustion of Cochituate Lake and the

water supply. The early winter was characterized by ample falls of snow, *which remained upon the ground*, in moderate quantity, the most of the winter through; while negative electricity was limited to but a very few, and only parts of days during the winter and early spring. The season and year, as a whole, passed off as very remarkbly healthful.

Now, we see that electricity, and light, heat, cold, and wet are so related that changes in the enormous tidal volumes of the former produce changes and combinations in the latter. When I speak of a clear, bright day, I do not mean the blazing, glaring, burning light we sometimes have, for this is the result of polarized light. A blue sky ordinarily yields a beautiful and delightful sunlight; we call it, and feel it to be, an agreeable and beautiful *light* of day. Hence it comes to pass that the term "delightful" is applied to the day itself: and well it may be, for all meteorological conditions are right at par, and all conspire to produce buoyancy, strength, and gayety of spirits; and, for the time, it actually overcomes many morbid, nervous functions, so that even the invalid may feel well, be happy, and rejoice.

When there are numerous white, fleecy (*cumulus*) clouds in the sky, the reflected light is greatly increased with polarized rays. Moreover, if our stand-point is exposed to local reflection, also, that is, not from bright clouds only, which more than any other reflection burns the skin, but to such as an expanse of water, or sand, or rocks; from slopes of land that face us, or from snow-banks, or the sails and deck of a ship, or the walls of buildings, — then there is produced a largely polarized light, which is not conducive to health. Such a light is trying to the eyes, degenerates the air we breathe by the reduction of its oxygen, and causes a decided diminution of electricity in the lower strata near the earth in which we live. For *blue sky gives back no reflected light*, and where or when it exists, it indicates a large positive electricity in all the higher strata of the atmosphere, and permits the existence of the same state in the air nearer the surface of the earth.

When it is ascertained, by aid of accurate instruments, that

the atmospheric and terrestrial electricities are weak, inert, or even negative, together with a humidity, and, perhaps, a general stillness of the air, and a prevailing diminution of immediate sunlight; or, on the other hand, if this occurs together with a blazing, lurid sunlight, with heat for a long spell, we may look out for cholera infantum, diarrhœa, dysentery, cholera, and typhoid fever; as also typhoid-bilious, intermitting, and remitting fevers in the so-called malarious districts. On the contrary, when the season is open and clear, with definite snows, rains, or showers, (according to the time of year,) with longer spells of clear, serene sky, the clouds broken into island-like masses, and the air moved by moderate westerly or north-westerly winds, the public health is generally good, no epidemic prevails, and the statistics of deaths are decidedly diminished.

*Meteoric Epidemics* are doubtless caused by certain, as yet, undiscoverable and insalubrious qualities of the general atmosphere over the country where they occur. Though traceable to a common origin, each epidemic, as influenza, typhoid pneumonia, erysipelas, dysentery, Asiatic cholera, diphtheria, brain fever, or spotted fever, or cerebro-spinal menengitis, &c., is marked by peculiar phenomena. In the strictly *contagious* epidemics, it has been shown that the great majority of cases spring immediately from specific poisons generated in primary cases, such as the exanthematous epidemics, viz., small-pox, measles, scarlet fever, and hooping-cough, and are communicable from one individual to another; whereas in the meteoric epidemics, excepting one or two of them, every case is of atmospheric *origin;* and in the now and then exceptional instances, as in cholera and believed to be more or less contagious, the greater portion of cases evidently arise not from the diffusion of its contagious virus, but *from the prevailing or existing meteoric influence.* Now, is this *all* owing to *ozone*, or the deficient, or excessive, or as yet unknown, action of atmospheric and terrestrial electricity? Who will tell us, that we may know when and how to meet it!

*The Ozonoscope.* — A test for ozone is made of a slip of paper or cloth, on which has been spread a compound of ge-

latinized starch and the iodide of potassium. Ozone, acting the part of an acid, unites with the potassium in forming potassa, liberating a certain portion of free iodine. The iodine, thus set free, unites with a portion of starch, showing the blue iodide of starch. The depth of this blue demonstrates the amount of ozone present, or, in the language of science, the chromatic intensity becomes the measure of ozonized quantity. MM. Trémy and Becquerel have demonstrated to the scientific world in their joint work — Electro-Chemical Researches on the Properties of Electrified Bodies — that ozone is but oxygen in the characteristic state induced by its subjection to electricity. The ozonoscope, in the presence of either oxygen or electricity singly, or even when they alone are combined, remains unchanged; but as soon as the oxygen is electrified *in the presence of a little hydrogen*, ozone is distinctly manifested. The iodide of potassium is the real agent for test; the starch only indicates the extent of its action. Not all, nor the one hundredth part of oxygen exposed to the action of electricity, becomes ozonized; yet the minutest portion of ozone can purify the most baleful exhalations of any and every description whatever. *It will always purify five hundred and forty times its volume of impure air.*

Ozone can be artificially obtained for experiment either by electricity or chemistry. By Dr. Griffin's method, we take a piece of phosphorus about half an inch long, clean its surface by scraping while under water, then put it into a clean two-quart glass bottle, and add as much water as covers the phosphorus only half way; close the bottle with a loose stopper, and set it aside, at a temperature about 60° F. Ozone will soon begin to form in the air in the bottle, and in five or six hours it will be abundant. Remove the phosphorus, shake a little water in the bottle, and then throw that all out to rinse away the phosphoric acid. Repeat this washing several times. The ozone is not washed away, but still remains in the air of the bottle.

Ozone can also be made by passing a large current of electricity across the surface of water, which produces it in the greatest quantities.

It results from all observations accurately made that we now

must recognize the fact, that a certain combination of meteorological and geographical or geological conditions is necessary, or is especially favorable, to the production of a well-known class of prevailing depressing, nervous disorders, such as ague, intermitting and remitting fevers, and their complications. I shall take *ague* as a type of the whole. It has been often observed how much extraordinary changes or long continuance of a given state of weather, as drought, heat, fogs, prolonged or heavy rains, at a given season, vary the result. If much water falls, the ponds are kept full, the great mud holes, and creeks, and wet lands remain completely under water during the hot season, and are harmless. The semi-low lands in the vicinity continue remarkably healthy during such a season. But this extra wet renders the uplands unusually moist during the same hot months. Now, we observe ague and periodic diseases to prevail at a distance from the low lands. So that *location*, as well as the *season*, affects the results, even in the same region of malarious country.

A certain kind of *soil*, also, or relative position of damp earth, together with heat, is necessary to the development of periodic ague and fevers. The whole phenomena of effect on man are *a reduction of nerve-force*, a deranged and damaged vitality. The prolonged dampness of a ship, or of various manufactories, will not cause it. Wet places, as swamps, if with a tendency to formation of peat, — even the extensive peat bogs of Ireland, — show no sort of influence to this result. There is an abundance of vegetable and alluvial matter in such wet meadows, woods, swamps, and marshes, but their composition, combination, or relation, renders them harmless; they do not produce the so-called malaria.

The simple decomposition of vegetable matter does *not* produce ague, — such as rotting compost heaps, mud from drains thrown up and exposed to the sun; nor manure with tons of straw and earth in barn yards; nor fields of decaying stubble. The concentrated process of rotting immense quantities of indigo plants, of hemp, and of flax; nor fields of rich clover ploughed under; nor fish heaps; nor fish and manure put into the hill,

or spread and ploughed in over a wide extent of country, — nor even miles and miles of damp and decaying logs, and leaves, and underbrush, in extensive forests, — will ever produce ague, *if not in an ague district.* None of these alone, of themselves, can be associated with the production of ague. (Dr. Hanfield Jones has drawn up a list of about a score of diseases allied to ague, — such as neuralgia, certain forms of rheumatism, neurosis of the *nervus vagus*, and of the solar plexus, &c.) Yet a certain sort of wet or moist cellar, under the dwelling, in connection with its damp stone or brick walls, or a half dried-up duck pond or mill pond near by, is sufficient to develop it in any country or latitude during protracted warm weather. The annually or semi-annually overflowed alluvial meadows along the margins of rivers, and the wet, low bottom-lands along sluggish creeks and bayous, are of course the more potent localities for ague. Therefore, although there doubtless is considerable vegetable decomposition in the air and earth where ague and its family of kindred affections originate, as a prevailing malady, as well as in other portions of the country where ague never occurs, still it is clear enough to any logical mind that there must be a mighty agency — beside and beyond the insensible bad air from vegetable decomposition which usually constitutes the idea of *malaria* — that brings about these uniform and formidable derangements of the nervous system.

On the other hand, it is well known that bad-smelling air can produce nausea, and depress the general powers of life; *but it will not result in ague.* Bad air, also, when impregnated with putrid animal matters, can produce erysipelas and typhus. Bad air from badly-ventilated and dirty houses, from foul drains and cesspools, from pent-up vegetable and animal decomposition, or from disturbed and exposed mud in docks and harbors, during the warm weather, may produce typhoid fever and dysentery even of malignant types; and if there is great heat, with prevailing negative electricity, yellow fever may appear, or some other manifestation of blood-poison will be developed; but no sort of ague, neuralgia, neuralgic rheumatism, nor other periodic disease, *if not situated in a meteorological*, i. e., *malarial*,

*region*, and if the locality is not rendered what is termed *malarious* by the draining of a pond or the extraordinary low stage of water in a contiguous creek or river. The poison, then, from foul air or water is quite another thing.

*Sewage* is that filthy mass — a more or less pulpy or fluid and gaseous compound — of decomposing or already rotten animal, vegetable, and other liquid substances, mingled with that from water closets, which together flow through large sewers in towns and cities. Fresh, and well-watered, and free-flowing sewage has but little effluvium, is even food for fishes of various kinds which haunt the outfall of the sewers, and become large, fat, and powerful; while *putrid* sewage, which has been festering in cesspools, or lingering in badly constructed sewers, befouls the air, taints the water, and kills the fish. Thus sewage is too filthy to be let into a river or harbor, too valuable as a fertilizer to be wasted, and too pernicious to health to be exposed and neglected. It should be saved, deodorized, and prepared for irrigation: thus, on the one hand, avoiding disease, and, on the other, improving the lands.

A severe outbreak of dysentery has recently occurred in a country asylum in England, caused by the effluvia from a field surface manured by fresh sewage. The poison had a period of incubation, in most cases before the dysentery appeared, of from three to five days. The morbid appearances most characteristic of this epidemic were, a soft, membranous deposit in the mucous membrane of the intestines, and a diseased condition of the lower part of the small, as well as the large, intestine, in all the cases. There were also many cases of diarrhœa and typhoid fever traced to this same source, viz., "fresh sewage applied in warm weather immediately on the surface of a field with a stiff clay subsoil within three hundred yards of the buildings."

Dr. H. I. Bowditch, of Boston, — than whom a more learned, accurate, and indefatigable medical topographer does not live, — has for many years kept up prodigious research, particularly in the State of Massachusetts, "with peculiar reference to the relations and effects of location of residence, and the topography of the vicinity, *to the cause of consumption.*" To this point his reports

are exceedingly interesting and instructive. I am persuaded that one very essential point, relating to this whole subject, has been comparatively overlooked by nearly all investigators, and that is, *the relation of the dwelling house itself to the earth and sky* — as a medium for meteorological passes and changes.

If the cellar under the residence of a patient (already sick, or feeble and impressible) is wet, or very moist and close, aside from the dampness, or bad air, the foundations and walls of that building are in the precise condition to become the best practical medium, in that locality, for the transit of vast volumes of meteoric influences, particularly during all varying and extreme weather, from the air to the earth, and *vice versa* — thus further deranging the already enfeebled nervous and vascular system. It is well known that if a positive current of electricity pass up or down those walls, all in that house are rendered negative, and are retained so, especially through the night hours. Robust members of the family, who spend much of their time out of doors, are not sensibly affected, perhaps; but the invalid, the little child, or the sick, may be influenced by it, with all this odds against their progress or recovery.

To this point, viz., *the importance of a dry foundation and a well-ventilated cellar under the residence*, — be the elevation, the situation, the climate, and other relations what they may, — I wish to call the particular attention of every medical man. To our mind, — and we are not alone in this opinion, — sanitary reasons require that no new dwelling house should be allowed to be built unless these conditions can be fully attained. True, a wet cellar may be cemented or drained; but if it is very moist, be the nature of that *influence* meteorological or malarial, still is there tangible evidence of a debilitating and decidedly unhealthy influence. A cellar that is so wet or damp as to require draining or cementing is not fit to be under a dwelling house. Notice the effects of the sulphuretted hydrogen on the table silver if left for a time in a closed closet of such a house. Notice the musty smell of the carpets and beds in a room of such a house if left shut up for a few weeks. Notice how much *more prevalent* are neuralgia, rheumatismal affections, decline, consumption,

and other chronic diseases of debility in such habitations. Observe the inefficiency of medication while the patient remains there, and the rapid improvement as soon as he or she is removed, if timely done, provided the new house is a dry one. May not typhoid fever itself be induced, in part at least, by some such aiding cause, limited, perhaps, to the given house, although the situation may be elevated, and in the open country? for the subsoil, or some deeper stratum, may be clay, hard-pan, or rock, so that such a foundation may be actually wet. A leaky roof is a less evil, so far as health is concerned, than a wet or very damp and close cellar.

The relations of physical objects and influences which surround a people of a given locality are interesting, aside from the bearing on health, because of the formative influence they exert on *personal peculiarities*, as of constitution, stature, beauty, and of mental and moral character. The distinctive peculiarities of an individual are in part derived from the inherited physical organization, and in part from other local and social influences, as government, religion, education, national customs, individual habits, and avocation. Temperament is determined, in a great degree, by the effects of climate on themselves, and on a line of ancestry, and other local influences to which a person or a whole people may be subjected.

The relations of color of skin, even after many generations, and other physiological developments, as the elevation of hot countries above the level of the ocean, are precisely the same (according to the observations of Dr. J. M. Smith, of New York) as they are to the increase of latitude: that is, high elevation in the low latitudes produces the physical phenomena of low situations in the high latitudes. Accordingly, at various elevations in the same latitude are found diversities of complexion, stature, and temperament. From this law may be deduced the probability that in the process of time the southern great plateaus and slopes of the Rocky Mountains will produce a vast population of men and women more ruddy, sanguine, large, and robust than the native residents of the southern and eastern Atlantic states.

Such specimens of a noble physical and mental race are very noticeable to the traveller through all that extent of "hill country" stretching from Maine, through New Hampshire and Vermont, down to the south-western slopes of the Green Mountains into Berkshire county of our own Massachusetts. Indeed, during the summer months, my own family seek this peculiarly delightful, dry, salubrious atmosphere, and the plain farmer's fare among these hills, on Winchendon Common, in sight of the grim old Monadnock Mountain, and thus uniformly cumulate health and strength while away from their city home. Thousands from our cities, during summer, wisely seek the atmospheric luxury of these young mountains in Ringe, Jaffrey, Bethlehem, Keene, Royalston, Clarendon, and Jefferson. Here the nights are cool, but not chilly; the days bright and breezy. The water is from magnesian beds of marble-cool, brilliant, and sparkling springs; the air so clear that speech is easy and musical. Fogs are only seen below on the low lands, and in the distant valleys, whence come the scream of the railroad whistle and the hum of the busy factory villages. Chilly nights and sultry days are only found there, and in the gorges of the greater mountains above, far away to the north. A residence as elevated as this, if at the base of a still higher mountain, is subject to fogs, damp air, chilly nights, and sultry days.

To these varied physical peculiarities of the American people, or a large portion of them, may be added their early maturity of body, precocity of mind, versatility of talent, adventurous spirit for the sea, for exploration, and for enterprise, and an eagerness to gratify a restless curiosity — the last two peculiarities, however, being more characteristic of the northern and eastern than of the extreme southern people. "The genius of our country," says Dr. Samuel H. Dickson, in his Essays on Life, Sleep, Pain, &c., "lies in exaggeration. We *must go ahead.* There is no resting-place for our unquiet temperament. No principle is worth asserting with any modification; no enterprise worth the undertaking, if it have a limit. We Americans coax forward the child at its mother's knee; urge, with sharp spur,

the boy at school; stimulate in every way the adolescent mind, whether in the field, the workshop, or the college class; and having succeeded in giving every faculty the habit of ceaseless action, we find that repose has become impossible or intolerable." How true to the life is all this among us! and yet people express surprise at the prevalence of nervous diseases.

It is profitable and interesting to know, in this connection, that Meteorological observations have now become multitudinous. These, conducted by so many scientific persons, and in so great a number of countries, as well as under so great a variety of circumstances, and that for so many successive years, appear to us calculated to inspire the greatest confidence, so far as the facts are agreed upon. The following table, formed by the distinguished De la Rive, has made manifest the following concise results: —

1. Whatever the state of the sky may be, the electricity of the air presents a maximum or *greatest* tension in January, and a minimum or *least* tension towards the summer solstice.

2. The difference between the maximum and the minimum is much more sensible during serene weather than it is during cloudy weather.

3. During the different months, generally, the electricity of the air is more powerful when the sky is serene than when it is cloudy, excepting towards the months of June and July, when the electricity attains its maximum; the value of which is nearly the same, whatever be the state of the sky.

Thus, setting out with these views, the electricity of the atmosphere during a serene sky exceeds the electricity observed during a cloudy sky, and so much the more as we approach nearer to January. *In this latter month the ratio is more than four to one.* Now, this powerful atmospheric electric intensity, during the serene sky of winter, is a very remarkable circumstance. This has been again and again proved by philosophers, who have been especially engaged in observing the phenomenon of atmospheric electricity, but who appear to give it a less relative value.

*Storms.*

Mr. Quitman has collected tables of observation made during extraordinary circumstances, such as in times of snows, rains, and fogs. He finds that under certain conditions, a powerful electric atmosphere obtains at the *approach* of a rain storm, and after a rain storm, which is sometimes positive and sometimes negative. The electric intensity observed during fogs has a mean, the same as that obtained during snows, and is not much influenced by the time of season. The value of electricity observed during a tranquil rain, differs very little from the mean taken in the course of the whole year. The electricity of the air estimated at an elevation always the same, suffers a *diurnal variation*, which generally shows two *maxima* and two *minima;* and these are displaced according to the different epochs of the year. The first happens before 8 o'clock in the morning in the summer, and at about 10 A. M. in the winter. The second maximum is after 9 P. M. in the summer, and about 6 P. M. in winter. The day minimum is found to be about 3 P. M. in summer, but near to 1 P. M. in winter. The night minimum is as yet not so exactly obtained.

Observations accurately taken at all even hours Greenwich mean time, and that unceasingly for three years in succession, — during the nights as well as days, — shows that the tension of atmospheric electricity is at its minimum at 2 A. M. Setting out, then, from this hour, and we find the tension increases more rapidly, so that its value at 8 A. M. becomes almost double of that at 6 A. M.; but from this hour the increase becomes more gradual again until 10 A. M., the period of the first or morning maximum. Now, again setting out from this last-named hour, the tension declines gradually until 4 P. M., a period at which its value is only slightly superior to that of 8 A. M. This second minimum is called by the French philosopher De la Rive the *diurnal minimum*, to distinguish it from the *nocturnal minimum*, which takes place at 2 o'clock in the morning. After that hour (4 P. M.) the tension increases rapidly until 8 P. M., and

after a slight further rise until 10 P. M., — the period of the principal or evening maximum, — when the ascending march of the electric tension is terminated. The evening maximum is very notably superior to that of the morning, or say at about 10 o'clock. Between 10 in the evening and midnight, the tension of atmospheric electricity is decreased almost to the value of the diurnal minimum. It is occasionally observed on the same day that where the instruments mark 150° to 200° at the morning maximum, it runs down during the day so as to show only 3° to 4° at the afternoon minimum ; but it usually happens that variations so great are immediately followed by storms.

We find that the air under a perfectly clear and serene sky, and when there is no storm within two or three hundred miles of us, is constantly, but moderately, positive ; but this is not always uniformly distributed through all the strata of the atmosphere. It is found more nearly of the same intensity in a given horizontal stratum, but uniformly stronger in the upper strata, and stronger still in the ratio as we rise through the successive strata. But at the lowest stratum, i. e., at the surface of the ground where the air and earth unite, the electricity of the air is *null*. In the open country it does not commence to be sensible to most delicate instruments until about a yard or two above the ground. Where there are large trees, buildings, or other elevated bodies, the evidence of its lowest positive pressure is to be sought still higher ; i. e., more elevated from the ground.

The air and the earth are believed to be, as a whole, charged with different electricities, which are continually tending to recombine, and are perpetually doing so, by varied degrees, in the lower strata of the air, some directly by the dry land, but much more through good conducting bodies that are upon the surface of the earth. This is because our globe is *magnetic*, and charged with negative electricity (magnetic ?), although constantly uniting with the positive of the air ; so that over all the surface of our earth, for a very few feet deep, the air is found at a near balance, i. e., neither positive nor negative, and the needle of the electrometer is here almost constantly at zero.

Now, we see that if each drop of rain, or each flake of snow, is of the same kind of electricity with which the globules of the clouds were charged, and of which they had indeed served to form a part, — the whole even, by their agglomeration, — it is easy to conceive how there is an electric change brought about with every fall of rain, hail, or snow, since this is carried onward with them in their fall. Each drop of rain, and each flake of snow, is doing a work that not only causes the electrometer and the barometer to fluctuate, but also causes joints, nerves, and bones to feel and confess their united power. Says De la Rive, wherever it rains there is a region of country, or sea, that for the time is charged with positive electricity; that this region is completely surrounded by a zone on all its border, but entirely outside the rain and storm, that is, charged with the *negative electricity*. Suppose there is rain falling at a very great distance from the place of observation, but which is approaching, and then soon arrives there under the action of the wind, and then passes onward and over without ceasing to fall, until all is passed. In that case, the following is the order in which it occurs, i. e., as the storm clouds approach and pass away: —

1. When the rain is very distant, the instruments indicate positive electricity in the air, as they do almost always, and even this with some considerable degree of tension.

2. When the rain has approached within a certain distance, we find a *strong negative electricity;* and this not unfrequently produces sparks to the fixed conductor.

3. When the rain has reached the place of observation, a great quantity of positive electricity has rapidly come, as found again indicated.

4. When the rain has passed over and gone, we now have again a strong negative tension; but this for a very short time.

5. Finally, when the rain is sufficiently distant, so that the zone also has passed off with it, the atmosphere returns to its habitual equilibrium or mean; i. e., for the time of clear weather; of moderately positive electric tension. Therefore we can recognize in this a law of three marked electric changes. First, that at the approach of the storm, which is *negative*. Second,

that which prevails during the storm and fall of the rain or snow, which is *positive*. Third, that which follows close on its departure, which is again *negative;* but that this latter is not so marked, or of so long duration; and this is again succeeded, as we have said, by that clear, serene sky that we call a *pure atmosphere*, possessing its full quantum of natural electricity, and no more. It is believed that negative or neutral rains do not come; that negative clouds do not exist. When the air is perfectly pure, the upper stratum of it is electrized positively in respect to the lower strata, while at the same time the surface of the earth is nearly neutral, and hence the electricity of the atmosphere must increase as we rise. To test or prove this, M. Becquerel ingeniously employed arrows shot from a cross-bow. To the arrow, when shot, was attached a fine silk thread neatly covered with tinsel, the other end of which communicated with an electroscope. He thus fairly and beautifully demonstrated the increased ratio of positive electricity in the atmosphere to be in direct proportion to the height in the air. He made this experiment at the Great St. Bernard, in Switzerland, and upon the top of one of those elevated plateaus near the Hospice.

But our space allows us merely to allude to all these highly interesting and instructive observations, made by the aid of the telling *Electrometer* for testing atmospheric electricity, as to quantity and intensity; by the *Barometer* and other instruments, for ascertaining the atmospheric density, *humidity*, ozone, &c.; or by the *Thermometer*, for its heat and cold. Such like meteorological observations made with much care, and that by all these present helps for testing and comparing the normal and abnormal electricities, and other states of the atmosphere, together with another class of observations for determining the *magnetic variation* in the earth, — simultaneously made on the land and on the sea, on different continents, in the extreme north and extreme south, as well as at the equator, — are to any philo-

Fig. 2.

sophic, or logical mind, full of significance, as relating to health and disease, life and death, in the great human family.

We will only remark very briefly, that with regard to the real electric state of the atmosphere, and of the terrestrial globe, philosophers have long differed. But of late, Arago and De la Rive have concluded and do now assume, that our globe possesses, at least on its solid surface, an excess of accumulated negative electricity, and that this is the same with bodies on its surface; that the atmosphere itself, on the whole, is positively electrized, and arises from the same source as the negative of the globe. They noticed that when the most highly charged storm clouds approach mountains, the clouds go towards them with a rush, and with that quickness in proportion as the summit of the mountains have the more marked negative tension. They are then observed to linger, and adhere as it were to the mountain, as if indifferent or slow conductors, yielding successively either electricity. This, we notice, is observed only in respect to *static* electricity. If, now, we consult the galvanometer, we find phenomena for study in *dynamic* electricity. For when the cloud approaches the mountain, and as it commences to pass, the instrument gives indications of *ascending* currents, because the electricity of the ground is found to be attracted towards the clouds; and very frequently have we witnessed the clouds of dust and trash violently raised, not by the wind only, but by this force. And all this is reversed, as soon as the rain pours down, for it brings with it the superabundance of positive electricity from the clouds. At each clap of thunder, or rather at each flash of lightning, the needle of the galvanometer is agitated, and even driven back with force against its stops. At other times the magnetic state of the needle is found to be permanently altered from so great atmospheric electric influence.

### *Difference between Electricity and Magnetism.*

M. Becquerel contends that all bodies are more or less magnetic. The action of the magnet, it is known, was for a long time regarded as a special action exercised only upon certain

bodies. Now it is acknowledged to be all but universal, and perhaps quite so; for most bodies are found to be susceptible of experiencing its influence, although not endowed with magnetic properties. The action of the magnet is identical with the action exercised by closed electric currents, *exterior* to the circuit which they are traversing. This *law* is now admitted by all, for the identity rests at once upon experimental and mathematical proofs. Magnetism of the earth is perpetual; but it is not a state of oscillation, but of ceaseless fluctuations, for its changes, from moment to moment, are found to be strictly simultaneous at every point of the globe wherever observations of this nature have been accurately made. In this respect magnetism differs from electricity.

| *Magnetism.* | *Electricity.* |
|---|---|
| 1. The intensity of the magnetic force in different parts of the earth is according to the distance from the poles. | 1. The intensity of electric force is greatest at the tropics, and diminishes as it approaches the poles. |
| 2. The frigid zone, where magnetism is in the greatest intensity, enjoys an atmospheric calm which is unknown in temperate regions; it has no storms, no hail, and scarcely a tempest. | 2. The most vivid lightning and the loudest thunder are peculiar to the tropics; here vegetation is vigorous, and active at all seasons. |
| 3. The splendor of the aurora borealis, reflected by the snow, dispels the darkness of the polar night, but is not accompanied with danger. | 3. Igneous and fiery meteors, fire balls, and lightning are the peculiar electrical phenomena of the tropics. |
| 4. Magnetism suspends the decomposition of vegetable and animal matter. | 4. Electricity assists decomposition in all vegetable and animal substances. |
| 5. In northern latitudes the mercury of the barometer always stands high; in the temperate latitudes it is liable to frequent variations. | 5. The mercury of the barometer is always low in the torrid zone, and varies but little during the changes of weather. |

Whenever a current of electricity, great or small, is running in any given direction, there magnetism is always manifested exactly across it; that is, at right angles to this given direction.

6. The northern currents of atmosphere, accompanied as they are with magnetism, have the power of expansive action on the mercurial column of the barometer, wherever it may be placed, either in a warm room, or in the open air.

6. The southern currents of the atmosphere, accompanied with free electricity, cause a fall of the mercurial column under any circumstance of position of the barometer.

7. Snow from the north-west wind has been found to contain more oxygen than rain or river water, and more carbon.

7. Electricity causes the rain to descend with less oxygen than snow water; and less carbon also.

8. The magnetic intensity of the earth is indicated by needles suspended vertically; and in sailing from England towards the north pole, it is seen that the needle dips, or inclines more and more, with the increase of latitude, till at a certain point it remains exactly *perpendicular*, with its south pole downwards.

8. In sailing towards the equator, with a magnetic needle suspended in the like manner, the inclination or dip gradually decreases, until the needle rests in a perfectly horizontal position.

The above are some of the reasons which have induced me to think that magnetism and electricity are not strictly identical, their operations being as distinct as heat and cold; and I have therefore come to an analysis of the influence of the winds, and a theory to establish something of a definite character. Winds are not decisive as to their influence on health, when continually changing; that is, not remaining in any fixed quarter for two or three hours at least.

On the earth's surface, then, we have frequent changes of wind, and this more particularly in temperate latitudes, or cli-

mates; and hence there are frequent alterations in the atmosphere as regards both temperature and electro-magnetism. Sometimes a wind, well known for its peculiarly mild character, assumes so different a nature as to be mistaken for a wind from altogether another quarter of the globe. This arises from various winds supplying one current of air. For instance, we have a south-west wind of some velocity, of a stormy nature, and highly charged with electricity. Suppose, then, this wind to have a parallel breadth of any number of miles, and then to be supplied by north-east and north-west winds; of course, under such an influence, we shall have a great reduction of the temperature, and other qualities somewhat reversed, for a time, at least.

A north-east wind, on the other hand, will frequently have its real nature or character altered, owing to rapid changes of aerial currents during stormy or thundery weather; and this happens more particularly when the observer is situated on the external edge, as it were, of a parallel but contrary current of wind, which varies in diameter, at various seasons, from ten to one hundred miles; and hence an unusual temperature is given to it. In the centre, however, of the said parallel current you have the true quality unmodified.

We now come to the question of health and disease, under the operation of the several winds. The north wind (I here refer to the magnetic north) has a different influence on different constitutions and ages. The temperature of this wind of course varies, as has been before intimated, according to the seasons; but its general characteristics are always alike. This wind is usually unattended by hail, or even snow, although if a few points to the eastward it will often be followed, in the winter season, by the above phenomena.

### *Electric Relations of the Earth to its Atmosphere.*

The results obtained by M. Pelletier are, —

1. That the electricity of the air increases directly with the distance from the surface of the earth — a fact of great im-

portance, as it influences the determination of the question whether the electricity of the earth be derived from planetary space, as Pelletier affirms, or whether, as Professor Faraday thinks, it be the result of various processes taking place on the surface of the earth.

2. The measure of divergence of the electrometer being the measure of force, it was found from a series of daily observations, extending over a period of five years, (1854–9,) that the quantity of electricity at the same place, undergoes a regular increase and decrease in certain months of the year; that, contrary to general belief, the quantity of electricity is at its *maximum* in winter, and undergoes a decrease until it finds its *minimum* in June, and then again rises to its maximum in the succeeding January.

The subjoined table represents the numerical results; and from this it will be seen that at the same level the quantity of electricity in the atmosphere is *twelve times as great* in the cold month of January as in the hot month of June.

*Average of Five Years.*

| Months. | Quantity of Electricity. |
|---|---|
| January, *maximum*, | 605 |
| February, " | 378 |
| March, " | 200 |
| April, " | 141 |
| May, " | 84 |
| June, *minimum*, | 47 |
| July, " | 49 |
| August, " | 62 |
| September, " | 70 |
| October, " | 131 |
| November, " | 209 |
| December, " | 507 |

3. *The Influence of the State of the Sky.* — From the results under this head, it is made evident that the highest degree of electricity is not found in cloudy weather, but rather in the clear, serene sky; i. e., at a time when the atmosphere is free from

may be represented — cloudy 186, clear 273. In reference to the monthly variations, as influenced by the state of the sky, it was found that in January, the maximum month of the year, the proportionate quantities are, cloudy 268, clear 1133. Only one exception, for an equal number of cloudy and clear days, was met with to this rule, viz., in July; the electricity on the cloudy days was 41, on the clear days 35.

4. As regards fog, snow, and rain, it was observed that the amount of electricity was the same during the two former states of weather, and was double that observed during rainy weather — the latter corresponding to the minimum of the annual electricity, the former to the maximum of the year.

5. *As to the Kind of Electricity in the Air.* — It was noted that during a period of five years, only twenty-five observations gave evidence of resinous or negative electricity; the rest consisting of eighteen hundred observations, which indicated vitreous or positive electricity. The negative observations were all recorded after storm or rain, or some other great meteorological change. The normally electrical state of the atmosphere may therefore be considered as *positive*.

6. *Wind.* — It was observed that when the wind was E. S. E., or S. E., two maxima were regularly formed, and two minima when at W. S. W., and that these corresponded with the other variations which have been mentioned.

7. The diurnal variations were recorded during the same period of five years, from six o'clock in the morning until nine at night. The degrees of divergence showed that there were two maxima and two minima daily. The maxima were at 8 A. M., and from 8 to 9 P. M., in opposite periods to the magnetic maxima. One minimum was from 2 to 4 P. M.; the other, probably, during the early morning hours.

Prof. Faraday says, researches on the electricity of the air are not only interesting in a meteorological respect, but intensely so in a physiological and pathological point of view. While they account for storms in cloudless skies, and for the occurrence of severe storms during the winter, or in very cold latitudes, as at Cape Horn, for instance, (the Cape of Storms,) *they*

*tend to throw light upon the exacerbations of disease* at different hours of the day, as well as on the increase and decrease of epidemic and other diseases in different months of the year. Such remarkable changes in the electricity of the atmosphere cannot go on without affecting the static electricity of the human frame. According to the researches of Casper, of Berlin, the greater number of deaths from disease take place at the early hours in the morning, when the quantity of electricity in the air is reaching its *minimum*. Is this merely a coincidence, or is there some yet undiscovered connection between the cessation of life and the electrical state of the medium in which the human body is placed?

### *Weather Observations.*

We may usually know of the rapid approach of a regular north-east storm, sometimes even before the barometer, or the change of wind, announces it. The sudden appearance, no matter when, of those high-flying, delicate, and extensive *cirri* clouds, perhaps during a most delightful day or night, or in a spell of steady, settled, fine weather, is the sure forerunner. These *cirri* are always wavy, small, and high, somewhat resembling a sand flat or beach whose surface is left wavy by the ripple of the ebb tide. This fine wavy appearance is soon overlaid, or interspersed, here and there, with patches of *striated* clouds — not in straight lines, but always a little curved, and hence termed by sailors "*horse-tail clouds*." My students are led to term them *mackerel and flax clouds* — the sure indicators of an approaching change of weather, and most probably a storm.

The British Board of Trade has seen fit to publish, for the use of seafaring men, general maxims of weather, because the *color* of the sky *at particular times* affords, with the barometer, good collateral weather prognosis. Not only does the "rosy sunset" presage fair weather, and "a ruddy sunrise" bad weather, but there are other tints which bespeak with equal clearness and accuracy. A *bright*-yellow sky *in the evening* indicates wind; a *pale*-yellow, wet; a neutral gray color constitutes a favorable

sign in the evening, but an unfavorable sign if in the morning. The form and appearance of the clouds themselves are full of significance. If their forms are generally soft, undefined, and feathery, then will the weather be fine. If their edges appear hard, sharp, and well defined, it will be foul. Besides, generally speaking, any *unusual* hues, as the deep, dark, or very gay, betoken wind, or some falling weather, (rain, snow, hail, &c.;) while the more moderate and delicate tints bespeak fair weather.

### *Lightning.*

M. Arago says there are three kinds of lightnings — the *forked*, the *sheet*, and the *spherical*. The forked lightnings are in slender white or bluish streaks, that are zigzag or crinkled, and sometimes divided or forked. This is the most common kind. The sheet lightning, he says, is uniformly of a dull red appearance. The spherical are the same as *thunderbolts*, which descend more seldom and slowly to the earth, according to a law of their own, rendering lightning rods, as for them, useless. But there are also recognized two *kinds* of electricity in the atmosphere, so that the one or the other is always prevailing and affecting the health of mankind according to the weather; or, rather, according to the prevalence of this or that kind of electricity, so is the weather. The one is vitreous or positive, the other is called resinous or negative. These two forms of electricity are produced in the atmosphere itself from various causes — chiefly from evaporation, more also from condensation and separation of its moisture; from vegetation, from combustion, and from friction. This latter arises from large masses of air, moving in contrary directions, and thus encountering or chafing one another. The friction on the edges of such currents develops free electricity, which is more especially active when these moving masses of air, arising from different quarters and at different altitudes, differ also in their respective degrees of moisture and temperature. The cold develops negative electricity, the warm the positive electricity. Thunder storms, then, are the result of the approximation of vast quan-

tities of opposite electricities, positive and negative, or plus in one and minus in the other, according to Franklin. There is usually thunder with the lightning, but there are lightnings without thunder, and so are there thunders without lightning.

Meteoric iron, called *thunder-bolts*, have been found in our own country, and in other parts of the globe — ponderable, tangible bodies; one of the most marvellous specimens of which, I think, is to be seen in the cabinet of Yale College in New Haven.

### *Safety from Lightning.*

It is often asked of us how to avoid the danger by lightning. We usually advise on general principles, rather than give specific directions. Persons who are perspiring copiously, or are wet, are, on the whole, more exposed to danger by lightning than others whose skin and clothing are generally dry. The dress is truly important; but the casting away from one's person, and every way avoiding the locality of metals, as coin, scissors, pocket knife, or the proximity to the butt of a tree, or chimney, or iron, is also important. It is best not to stand in the doorway, nor yet by a window, particularly if it is open, as the warm air of the house acts as a conductor, and in that case attracts the lightning. Ladies dressed in silk, if with no jewelry, having a dry skin and clothing, are the least exposed of all persons. After having divested one's self of coin, jewelry, &c., then the next best thing to be done is to seek a position in the middle of the room, on a bed, or *any where away from conductors; also avoiding the range between two conductors.* Dr. Franklin's advice was to avoid the fireplace. I say avoid, also, the proximity to stove or gas pipes, water pipes, and lightning rods. Such are prudent precautions, under Providence, and it is but wise and important to observe them; yet we must bear in mind, that there is no absolute safety, as lightning will not *always* respect silk and glass, nor human wisdom. A person may be struck with lightning and yet not be killed; they may receive only wounds or laceration, or these with death. The victim may bear the traces of dreadful burns, or singed hair,

but these are the *indirect* effects of lightning. *Its direct action* on the human body is a shock, more or less great, and this by exhausting the human nerve-batteries more or less; when complete, it leaves the body a mass of disorganized matter, and instantaneous death is the consequence. When wounds are produced they are usually in some internal vascular portion, and from which there is an instantaneous and frightful effusion of blood, &c., and hence death in these cases is also necessarily immediate. In these cases there is an utter disorganization that admits of the immediate and most revolting putrefaction. But lightning now and then causes death by a simple shock, that appears to have been only just sufficient to exhaust the nerve-batteries, or modify them sufficiently to destroy life; and here, it is said, the bodies do not readily decay. Indeed, some persons may die from lightning only striking *near* them.

From the remotest ages, we learn that the various tribes and nations of men have devised ways and means as widely different as curious, to protect themselves from thunder and lightning. Among the more civilized nations, there was for centuries a resort to the ringing of large bells, because it was believed that this was capable of paralyzing the effects. This, indeed, was one of the greatest uses bells were first put to; hence are found on old bells in Europe the following inscription: *Vivos voco, mortuos plango, fulgura frango.*

Another *freak* of lightning is mentioned by M. Arago as a curious fact — that lightning has been known to strike, penetrate, and demolish powder magazines, and there upsetting and scattering the powder in all directions, and yet not set it on fire! This fact, though rare, — for the setting it on fire and producing an explosion is by far the more usual result, — illustrates *the law of damage to man;* for electricity by friction, as in that case of lightning, never burns, nor even explodes gunpowder, if it meets no hinderance; but rather follows an ample conductor. In this case it is too quick to fire, burn, or disorganize. It can be demonstrated that electricity or lightning explodes the powder; burns, tears, or disorganizes to destruction, only when it encounters in its route a given degree of resistance that actually delays its velocity.

A very rare, but instructive case, among the *accidents by lightning*, is given, which is designated by De la Rive, as "*struck by a return-shock.*" He says persons or animals may be struck by lightning at a great distance from a storm cloud. This is an effect of induction on a grand scale, yet of easy explanation. Whenever a storm cloud that is powerfully electrized approaches so that the person is situated within its sphere of activity, the natural electricity of this person is decomposed by actual induction. The molecules of the living body is naturally bipolar; now, that in the person of the contrary name to the electricity of the clouds is attracted to the cloud, while that of the same name in the person is repelled to the ground; the person therefore is found to be in a highly electrical state, but contrary to that of the cloud. But, if now the cloud happens to discharge itself from any point, say to a tree, or to a rock, and thus losing on a sudden a large portion of its surcharge of electricity, it is no longer able to retain the person who is beneath it in an electric state, contrary to that which now the cloud itself possesses. In fact, the electricity of the person's body was simultaneously and suddenly discharged to the earth, the same instant that the cloud discharged itself to the rock. The electric change which may thus result, may be sufficiently powerful to cause death, without leaving any visible trace of alteration, or the least mark of injury whatever, on or in the dead body. Besides, there are very many persons who have so little nerve power, or what may be termed *power of endurance*, that it requires but a slight, quick electric change to put out their taper of vitality, and, therefore, although in passing health, it might bring to them instant death, without leaving a trace behind.

### *Effects of Lightning on the human Organism.*

*Arborescent Marks from Lightning.* — It is my opinion that lightning stroke does *not* photograph the likeness of a tree, or any other object that may chance to be near the person when so struck, as has been so often reported. To the point: a recent letter from Dr. Bidwell, surgeon at Ship Island, near the mouth

of the Mississippi, gives the following account of the effects of lightning, as he witnessed it. In one of the violent storms peculiar to the latitude of the Gulf, a thunder-bolt descended upon the guard-tent, instantly killing three of the men, and producing serious internal injuries in three others, rendering their recovery almost hopeless, and shocking, more or less severely, some ten or twelve more. He says, "I noticed in the corpses of two, this morning, the peculiar and beautiful arborescent appearances on the chest and abdomen of *lightning stroke*. Had this occurred under or near a bush or tree, I suppose some would have designated it a photograph of the tree or bush. As it happened, however, there was not a tree of any kind or size within at least two miles of the spot, nor any thing resembling a bush or tree. This hypothesis must therefore be considered insufficient."

I have repeatedly explained to students that large and long sparks drawn from a quantity battery through a good Ruhmkorff's coil, so as to strike obliquely on the back of a looking-glass, demonstrates the arborescent action of this form of electricity. When the bolt or great spark thus strikes, it splits, much as would a drop of quicksilver if let fall, and flies off in many directions, but mainly in one way, and thus leaves its tracks behind it.

*Peculiar Effects of Lightning on the Human Body.* — From numerous cases carefully observed by various observers, Dr. Stricker, of Frankfort, has made a connected description of the usual visible effects produced upon the human body when struck by lightning. If sheltered under a tree, or near any indifferent conductor, the lightning, in passing from the tree, strikes a person usually first on the neck or shoulder, causing a burn, and much pain, with extravasation and congestion of the vessels over a broad part of the surface. From this a smaller stripe passes downwards, running to the nates, gradually getting less, and more superficial; but at the buttocks, where on man the clothes fit tighter, the conduction is more intense. The lightning from here is conducted upon the skin towards the trochanters on one or both sides, the marks becoming weaker, and so on to the knee, or a little below it, where (the dress being tighter about the

limb) it causes a deeper burning, then runs along the calf, and then, if boots are worn, it passes over and destroys them; or passes along the skin to the heel, and wounds it; and after piercing the shoe, makes a hole in the earth. Sometimes it passes along the ankle and foot, and so off to the earth. Or, from the hips, the lightning may be conducted along the trousers, which it destroys, or pierces with only a round hole.

When the lightning strikes a person freely exposed in the open field, then the head-covering is destroyed, and the vertex is smitten. From thence the conduction may be twofold: either, first, from the cranial bones to the brain, producing death by the simple or combined influence of the injury to the brain-mass, or by rupture of the blood-vessels; or, second, it may pass along the skin. In the latter case the skin of the face and neck is, if dry, almost always completely spared; but the lightning effects a considerable burn over the sternum. In some cases it enters the mouth, affects the tongue and teeth, causes bronchitis, loss of voice, &c. Proceeding downwards, the tract passes towards the inguinal region, the shirt only being sometimes torn; and then an interruption of conduction often occurs, occasioning deep burning of the genitals. Sometimes we have mortal laceration of the intestines, or, in milder cases, injection of the liver, spleen, stomach, &c. From thence, to the groins, the conduction is along the skin, or clothing, or both, to the heel, where a wound is produced. The burning of the hair is very remarkable, and this, in some cases, happens without any injury to the skin. So we find that burning produced by lightning is different from that of the galvanic cautery, varying to the mere drying of the tegumentary surface. The *general results of injury* by lightning are, —

1. In those killed, we find rapid putrefaction, and dilatation of the pupils. The hemorrhage from the nose and mouth which occurs cannot be explained.

2. Excessive stupefaction.

3. In those only partly outwardly injured, who survive, there is great alternate depression and exaltation of nervous action;

long-drawn and slow inspirations; small, slow pulse; cooling of the skin, and general muscular debility.

4. Suppression of urine and constipation; vomiting and loss of appetite; sometimes purging.

5. Great painfulness of the parts affected, which continues, or even increases, for about two days, and then declines. In some, existing deafness is cured; in others, some deafness is the result.

6. On the uterus of pregnant women no effect is produced; only, like a simple fright, it tends to arrest existing menstruation.

7. Cataract and nyctalopia may be an occasional result.

*Attitude of Persons killed by Lightning.* — This is peculiar. The first mention of this kind of death we find in the book of Job. In the history of Alexander, says Quintus Curtius, "During a dreadful tempest, which destroyed about a thousand men, many were found in the precise attitude in which death had surprised them." According to Carden, as quoted by Rirvière, eight reapers, while taking their food under an oak, were struck by lightning, and died instantly, preserving their attitudes as eating and drinking. A lawyer of Troyes was killed by lightning when on horseback. The animal, still continuing his journey, brought home his dead master, retaining the posture of a man on horseback. On July 11, 1819, at Château-neuf, three lightning fireballs fell on the church. Nine persons were killed, and eighty-two wounded; while all the dogs found in and about the church were killed, and retained the attitude which they previously had. In 1849 a goat was killed by lightning near Clermont, and was found still standing with a branch of green leaves in his mouth. So that at one time the individual is instantly killed dead upon the spot, and remains exactly in the same posture as when alive, while in another case he is thrown, perhaps, a great distance, or his limbs may be torn asunder.

*How* lightning kills, is a question that M. Brown-Sequard has studied much, and now assumes to answer. Some philosophers are every now and then extending their researches in the direction of *embryotic* life; but here we observe a scrutinizing philosopher and physiologist devoting his persevering attention to

the various phenomena of *death*.. From extended researches in this direction M. Brown-Sequard lays down the proposition that "every cause of excitement in the nerves and muscles must disturb their forces, and therefore acts in such a manner as to diminish the quantity (which means the power) of those forces that are found in the individual from moment to moment, and that in the exact proportion as this excitement is the more or less energetic." Hence he concludes, that lightning kills by exhausting the whole quantity of the dynamic forces, that are at that moment possessed by the animal economy; and therefore life must cease, because the vital acts cannot be maintained one moment without them. He supposes death to take place by asphyxia, or, as we may say, *by absolute collapse;* as after the extremely violent contraction of all the respiratory muscles, which is found to be produced at the instant of being struck by the electric shock, so that there is no spring left, no rebound of the natural electric polarity of the molecular structure of the nerves and muscles, for they are in fact totally exhausted and disorganized. This he illustrates by killing animals with the discharge of a powerful battery. He has found that if the discharge is directed through the diaphragm, it kills quicker and more surely than when directed through the head of the animal. It is also noticed that an animal so killed always opens its mouth in a few moments after the death stroke, as if gasping for breath, as it probably is; but there being no responsive motion of the thorax, this is scarcely repeated, and soon ceases altogether. The post mortem, shows a fluid state of the blood, and there is a general state of congestion in the liver, spleen, and cerebral vessels; while the lungs and the cavities of the heart are nearly empty! This is very different from that state of the heart found after death by chloroform, for there the left ventricle is enormously distended. It would seem from this, that after the diaphragm and heart gave their last great contraction under the stimulus of the lightning, there was no sort of dilating property left; that the body is now only a disorganized mass, ready for immediate putrefaction, because all vital force is extinct.

M. Boudin, a French philosopher who has made this particular

department of nature's rare phenomena the object of his protracted study, says there are three kinds of results produced on man by lightning: first, it can *cure* preëxisting affections; second, it can *produce* wounds and infirmities; third, it can *cause* death. He enumerates in his work, under the first order, as "occasional recoveries by thunder and lightning," amaurosis, deafness, roaring in the ears, paralysis, and rheumatism. He speaks of the phenomena as "unforeseen, various, appearing as opposites, involved in contrasts, and mysterious." He quotes the case of a man that was struck by lightning who manifested no appearance of life until an hour and a quarter afterwards, yet he entirely recovered his consciousness together with his undiminished intellect; but, strange to say, his sight was totally destroyed. His skin and muscular sensations were obtused, and his movements were very difficult. The various parts of his body no longer seemed to belong to him. But his taste, hearing, and smell were exquisitely augmented. His rest was poor, and his days were heavy. The general prostration was great, and this was attended with headache. Indeed, there was a veritable resolution of the general muscular forces; and the body in a degree was only a dead mass, mostly obeying the laws of gravity. He was burned and bruised, and these did not heal. Besides, he suffered from a succession of cramps. At the end of a month the pulse was low, frequent, and irregular. Galvanism was then here applied near the wounds and burns, as also an up-running current upon the spine, which caused immediate relief. He was soon observed to be improving. The galvanizing was continued from time to time, and, together with quinine, leeches, baths, and good nursing he gradually improved until it worked a complete cure. But it was four months before the galvanic treatment was discontinued.

Professor Olmsted, of New Haven, speaks of a man by the name of Samuel Leffers, who, having been blind for years, was restored to sight by a flash of lightning. M. Boudin mentions that somewhere in France, in August, 1846, there was a group of laborers struck by a bolt of lightning, when four were killed, and six were badly wounded. One of these men had on a goat-

skin coat, and on his body there were found the most frightful mutilations; and in three hours after, his body was as rigid as a mass of stone. So in some cases where persons have been killed by lightning, we may find the muscles rigid as if solid, while others are as remarkably flaccid. The blood is usually, if not always, as fluid as during life, or even more so, but probably never coagulated. Putrefaction commences most frequently at once, and goes on shockingly. But there are cases recorded where the corpse was found sound after a great length of time, as if petrified, or possessing some antiseptic property or state, that resists all decomposition. But mutilations very rarely occur in the human organism, while animals are very frequently broken and torn asunder. Dr. Boudin states, that out of several hundred persons killed by lightning, he found only six bodies that were mutilated; of these there were four of partial or total tearing out of the tongue. The great prominence of the eyeball is often produced; sometimes there is a small hole in the skull, as if shot. These different solutions of continuity may mark the route of the lightning in that individual case, but as yet we know of no law to determine it, other than circumstances — such as position of the body at the moment; the greater or less conductibility of the body, or of the clothing; the insulation, approximation, or line of direction for conducting the electric fluid *towards* him, or *from* him, in a direct route between the point where the bolt leaves its conductor to skip to a better conductor.

### *Effects of Atmospheric Electricity on the human Organism.*

The human organism is decidedly affected by atmospheric electricity, from the slighter changes in the electric state of the air, as well as by *bolts of lightning*. Healthy individuals even feel the exhilaration of a serene and positive atmosphere, as also an increased heaviness and oppression at the opposite state of the air. If the weather be stormy, and the air is surcharged either positively or negatively, or is suddenly changed from the one to the other state, then do we find the neuralgic, the rheumatic,

and all invalids feel pains and depressions. When the negative lower stratum of air, which is near the surface of the earth, obtains also in the higher strata for a while, as before a storm, and sometimes just after, then it is that the rheumatisms ache, and the neuralgias give their ugly twinges; the frail feel a peculiar fatigue and are irritable, or are perhaps drowsy. In the extremely sick, the dyspnœa of emphysema and of heart disease are worse; complicated chronic rheumatism is awaked, paroxysms of fever anticipate their accustomed hour; in severe acute diseases the symptoms are doubly alarming; while in fatal cases, death will arrive earlier in unsettled and stormy weather than would have been had the atmosphere been serene.

It is highly probable that this state of humid and negative air induces a large and sudden precipitation of the native electricity of the living body to the earth, which disturbs the animal electricity, changing the state of fibres, nerves, and organs; and this perturbates the regular functions that are so entirely depending upon the normal nervo-electric equilibrium.

One indirect effect of atmospheric electricity on the health of man is through ozone, which indeed is but a modification of the oxygen of the air from an electrical operation. The hypothesis of Dr. Boeckel makes a direct ratio between the diminution of ozone in the atmosphere at a given season, and the prevalence of cholera and of miasmatic diseases, as he believes he has demonstrated it at Berne and Strasburg.

Dr. Casper, of Berlin, has made extensive observations, which result thus: —

1. The greatest number of *births* occur between nine o'clock in the evening and six in the morning; while the smallest number occur between nine o'clock in the morning and six in the evening.

2. The pains of labor commence most frequently between twelve o'clock at night and three o'clock in the morning; least frequently from six to nine in the morning.

3. The influence of night is more marked with respect to the commencement of labor pains than with respect to complete delivery.

4. Among those births in which the pains commenced by day, the greater number were male children, and *vice versa*.

5. On an average, delivery was more protracted when the pains commenced by day than by night.

6. The preponderance of nocturnal over diurnal births is more striking in respect to children born dead, than in respect to those born living.

7. The *maximum* mortality occurs in the hours before noon, and the *minimum* mortality in the hours before midnight.

8. Individually regarded, the ratio of deaths from inflammations, phthisis, and pulmonary hemorrhage is greater in the afternoon; from fevers and exanthemata, just before midnight; from cerebral apoplexy, during the day; and from disease of the nervous system in general, in the hours which immediately follow midnight.

Dr. Thomas Laycock, when remarking upon the great prevalence, during last autumn, of diseases of the nervous system, makes the inquiry, whether the cause of this could arise from the nutritive functions having been less active.* Besides epigastric or hypochondriac neuralgia, he alludes to cases of quotidian intermittent tic-douloureux, or brow ague. In one case the painful ramifications of the upper cervical nerves were traced out by the patient; in another, the pain was limited to the infra-orbital branch of the fifth; and in other cases the paroxysms were accompanied by violent headache. Now, what is remarkable in these cases is this: —

The greater proportion of them, indeed, all, I think, without an exception, began or ended about the same hour of the day. There were two paroxysmal hours in the case of the man who had been working in low grounds, and who had been affected for two or three weeks; the paroxysms began regularly at 4 o'clock P. M., and continued to 4 o'clock A. M. He then got case, and went to sleep. And this was the case with several others. But the man with neuralgia of the supra-orbital nerve began to suffer at 8 or 9 o'clock A. M., and the paroxysm con-

* Braithewaite's Retrospect, No. 15, p. 28.

tinued until 8 or 9 o'clock P. M. Of course there is a reason why these hours are selected for the commencement and termination of the paroxysm. What then can it be?

In the first place, we find that the atmospheric tides attain their maximum and minimum at certain hours of the day, for there are tides in the circumambient atmosphere, as well as in the circumambient ocean; and therewith there are also changes in the electricity of the air and the magnetism of the earth. From 8 to 10 o'clock A. M. and P. M., the barometer is at its maximum height; the electric tension is at its maximum too; and there is also the greatest maximum variation east of the magnetic needle at the same hours. From 4 to 5 o'clock A. M. and P. M., the barometer is at minimum; and so is also the electric tension. It ought to be borne in mind, that there are other diseases which have a relation to these meteoric hours, but *principally those of the nervous system;* as those whose onset is dependent upon some predisposing condition of the nervous system. The respiratory movements, and of course the activity of the circulation, are in connection also with these hours. About 4 or 5 o'clock in the morning, with a minimum temperature, a minimum electric tension, and minimum height of the barometer, there is also a minimum consumption of oxygen. Further, I have ascertained by frequent inquiry that sleep to the nervous, generally comes on about that hour, after a feverish restless night; and, what is more remarkable, the statistics of deaths in the State show, that the mortal changes are in the proportion of three to two; that the last sleep — the sleep of death — will occur at that hour. Now, all these coincidences cannot be accidental; and as the operation of natural laws is as unerring as that of the most exquisite machinery, due investigation and inquiry only are requisite to lay bare this whole mystery.

Dr. Pallas, chief physician of the French army in Africa, asserts that the greater number of diseases, particularly the "neuroses," are due to the influence of widely deviating electricity; the principal sources of which are thunder clouds and marshy soils. By their geographical constitution, and their effects upon the human organism, *marshes* (says M. Pallas)

present the closest analogy to the galvanic battery. "Their deleterious effects are formidable in exact proportion with the quantity of saline or organic matter contained in the waters; and observation proves that diseases developed by the influence of marshy emanations are, at first, of a nervous nature; hence one of the methods which will be most efficient in preventing intermittent fever and neurosis, must be the *electrical isolation* of chairs, beds, and tables from the earth by glass supporters." But this hygienic measure is not found effectual.

*The Hour of Death in Acute and Chronic Diseases.* — The earliest attention paid to this subject dates to the time of *Ætius*, who flourished at the court of Constantinople in the fifth century. Slowly have facts accumulated for enabling the practitioner to estimate the changefulness of our condition in health, and also when illness supervenes; and to calculate when our vital functions are at their height, as well as to know when they are at their lowest ebb. Dr. Alfred Haviland, Surgeon to the Bridgewater Infirmary, England, has lately collected over five thousand cases of death, with *the hour of death* carefully recorded and tabulated in a grand chart. In one thousand cases of death in children under five years of age, the periods of the greatest mortality took place during the hours between one and eight, A. M., and an extraordinary depression took place in the succeeding hours. Between nine and twelve, P. M., the rate of mortality was at its minimum. He then compared these statistics with twenty-eight hundred and ninety-one deaths from all causes, and the chart shows how remarkably the wave lines of death compared with those above.

He then compared these with diagrams of deaths from consumption, which, although they showed a general resemblance in the wave lines, yet, between the hours of four to eight, A. M., there was a depression when compared with the first four-hour period. These tables prove the extraordinary mortality in the early hours of the morning, when the powers of life are at their lowest ebb. At these hours of night-morning patients are liable to be least cared for; hence the necessity of all the more attention and vigilance, aided by food and stimulants, to tide the

patient over this critical period, so that if death be in the end inevitable, a few more hours of life may be obtained; while with many a supposed hopeless case this point once passed, and many years of life, with health, have been granted.

### *Electric Changes the Cause of Epidemic Diseases.*

We know that Andraud made daily observations and experiments in and about Paris during the cholera there, which show a striking coincidence between the amount of atmospheric electricity and the virulence of the epidemic. In a letter to the President of the French Academy he says,—

The machine I have used for my daily observations is rather powerful. In ordinary weather it gives, after two or three turns of the wheel, brilliant sparks of five or six centimetres. I have noticed that since the invasion of the epidemic I have not been able to produce on any one occasion the same effect. During the months of April and May, the sparks, obtained with great trouble, have never exceeded two or three centimetres, and their variations accorded very nearly with the statistic variations of the cholera. This was already for me a strong presumption that I was on the trace of the important fact I was endeavoring to find. Nevertheless, I was not yet convinced, because one might attribute the fact to the moisture of the air, or to the irregularities of the electric machine. Thus I waited with impatience the arrival of fine weather with heat, to continue my observations with more certainty. At last fine weather came, and to my astonishment, the machine, though often consulted, was far from showing, as it ought, an augmentation of electricity, but gave signs less and less sensible to such a degree, that during the days of the 4th, 5th, and 6th of June, it was impossible to obtain any thing but slight cracklings without sparks. On the 7th, the machine remained quite dumb. This new decrease of the electric fluid has perfectly accorded, as is only too well known, with the renewed violence of the cholera; for my part, I was not more alarmed than astonished; my conviction was complete. I saw only the consequence of the fact already sup-

posed. It may be imagined with what anxiety, in these moments of the crisis, I consulted the machine, the sad and faithful interpreter of a great calamity. At last, on the morning of the 8th, some feeble sparks reappeared, and from hour to hour electric intensity increased. I felt with joy that the vivifying fluid was returning in the atmosphere. Towards evening a storm announced at Paris that the electricity had reëntered its domain; to my eyes it was the cholera disappearing with the cause which produced it. The next day (Saturday the 9th) I continued my observations: the machine then, at the least touch, rendered with facility most lively sparks. Now, it is stated that in the six days following the 8th of June, the mortality in Paris fell regularly from 667 to 355.

Another very curious circumstance is related by Dr. Kidd, of Limerick, Ireland, in the Medical Times of July of that year. While the epidemic was raging in that city, a large magnet, capable of sustaining seventy pounds, was watched daily. No variation took place in it. But on the appearance of the disease in Dublin, — one hundred miles east of Limerick, — the cholera being quite gone from the latter place, the magnet now suddenly lost nearly all its power.

Sir James Murray, M. D., who adopts Dr. Benjamin Franklin's theory of electricity, published a series of extensive investigations and experiments made by him, or under his auspices, some years since,* from which we make the following abstract from his own conclusions, and mostly in his own words: —

I consider, he says, that *the exciting cause* of epidemics, which is called *malaria*, is not "bad air" at all, as the name implies, but the result of disturbed electricity.

That marsh miasms, gases, or effluvia of vegeto-animal matters, or putrid emanations, are not, as is commonly supposed, the exciting causes of agues, or other diseases called malarious.

But I consider these noxious emanations are disturbed *electro-galvanic* currents and electric accumulations, — sometimes positive, sometimes negative, — causing a want of electrical equilibrium in human bodies.

That this protracted or often repeated disturbance, either in the relative quantity of electricity itself, or in the due proportion of the positive or negative, (fluids,) alters the conditions and functions of the human nerves, and

* These views are not wholly adopted by the author.

probably the relative state of the particles, and the polar relations of the atoms, or corpuscular molecules, and at all events is capable of exciting or depressing the vital functions, and of acting chemically on the circulating animal fluids. This is obvious near rivers, and during east winds; the agency of passive or negative electricity, then, and there, inducing diseases of debility.

That these untoward galvanic agencies account more clearly for the specific cause, specific symptoms, and specific cures of some classes of complaints, such as intermittents, than the hitherto assumed action of *marsh miasmata*, which are supposed to be so various in their nature. In regions in which there are no fens or marshes, such as the Island of Ascension, &c., the agues incident to strangers are the same as where morasses are extensive. In both circumstances, the disorders occur at particular seasons, are confined to particular situations, and require particular and identical treatment.

That the doctrine of marsh miasms is untenable, because malarious diseases attributed to them are common where there are no marshes, and because domestic animals are in general perfectly healthy, whilst human beings fall by thousands, which surely would not be the case were noxious miasms inhaled into the lungs during respiration.

The immunity of lower animals seems to rise from the comparative density of their integuments, rendering them less liable than man to the influence of electric accumulations, galvanic currents, or the disturbance of the (natural) fluid in them by induction. The hairs or wool being wet at night, serve as pointed conductors, which diffuse or dissipate opposite electrical currents into the earth or air, and prevent their effects on the small brain and nerves of domestic animals.

That the general immunity of blacks (even of those who have lived long in our climate) from malarious diseases appears to prove that inspiration of malarious air by the lungs is not absolutely noxious, and that the cutaneous texture, oily secretions, and non-conducting varnish of their daily anointing and painting, render their skins less susceptible or more repulsive of electric agencies than the integuments of whites. The black color, as it absorbs heat sooner than white, may also make a difference in the electric conducting power. Even a black silk thread, or ribbon, or stocking, presents very different electrical phenomena from those of white twist or white fabrics of the same texture.

That this doctrine of electrical origin of malarious diseases enables us to approach much more nearly to salutary means of prevention, than the old theory of inhalation of miasms wafted in the air can lead us to apply preventive measures against.

That for so-called malarious districts, wet floors, or low places, a thick layer of dry lime, fresh from the kilns, produces very favorable galvanic changes, abates the low indication of negative electricity of these places for the time, puts a speedy end to several chemical changes going on in sewers and soils, and tends very much to ameliorate the atmospheric condition of the

insalubrious habitations, in so far as electro-galvanic currents and accumulations are concerned. Dry lime is a non-conductor, and has been useful in absorbing the moisture of damp rooms, and thereby diminishing their power of carrying electric currents to or from the inhabitants.

The following may serve to convey an outline of my reasons for insulating public and private buildings. A cloud, strongly charged with positive electricity over the individual, will attract his negative electricity upwards, and repel his positive electricity towards the earth. After the cloud is discharged, passes away, or is neutralized, the two elementary fluids rush towards each other into the centre of the person's body. This action of the opposite currents of the two elements often kills instantly. In milder cases, such electrical disturbance affects the animal fluids, as it affects beer in the cellar or milk in the dairy.

I consider that men's bodies, between the atmosphere and the earth, represent the chain of a Leyden jar, or of an electric machine, conducting negative electricity from the outside of the jar to the ground, or supplying positive electricity from the earth to the rubber. Were the surface of the floor well *insulated*, the chain could not readily give or receive the currents which otherwise pass through it.

That by no hypothesis, deduced from the theory of miasms, can we account for the known fact, that in the Campagna di Roma, in Tuscany, Ceylon, and other places, localities are pointed out where malarious influence is insulated, and limited to defined spaces — as to one side of a hill, one range of a street, one end of a field, or even to one particular habitation. Malaria, tossed about in the air of Rome, will not account for one portion of the Via Babuina being infected, and not the other; nor will it explain why the dry and clean Pincian Hill, and the beautiful Monte Mario, are unhealthy, while the marshy streets and courts below are salutary; why the rich and well-planted grounds of the Villa Borghese are insalubrious, while the flooded Piazza Navonna, the Velabra, and the Jewish quarter are safe, like other crowded towns of equal temperature, on similar sanitary regulations.

That it is well known there are, even in these climates, numerous small spots of land, circumscribed by a distinct boundary, which have been noxious for ages. If this diseased state be owing to a want of equilibrium of galvanism in the earth or soil of such places, it merits a series of rigid trials, to examine their condition to the utmost extent, and to divert or cut off the sources of unequal galvanic influence, where unduly exerted. It is also known that, in various situations, physicians *cannot* readily cure or relieve certain nervous or rheumatic complaints, owing to causes which are undoubtedly electrical. This renders the removal from such localities absolutely necessary to sensitive patients, a change of air to whom, *is simply a change of habitual electricity*.

That we observe, by experiment, how various is the quantity of electricity required to charge different persons. The amount is shown by obtaining

sparks of the *same size*, from separate individuals, when equally insulated. Even their capacities for electricity, and their conducting powers, vary considerably. It is little wonder, then, that an endless diversity prevails in the ailments and sensations of persons who are so sensibly affected by what they call the state of the weather, damp, or the change of winds. These three enemies are supposed to be the actual perpetrators of injuries, which of themselves they have not the power to inflict.

Nature employs but few means to accomplish many ends. Electricity can produce thousands of effects; it is heat, light, galvanism, magnetism, and chemical action; or it is convertible into them. Its modifications constitute, in my opinion, that universal ether film which encircles all particles of matter, and preserves, by its powers of attraction and repulsion, the ultimate molecules of all organized bodies in their natural, relative connection and condition.

That, as a definite proportion of electricity belongs, and is peculiar to every thing, and as a natural quantity of it is essential to health, so any excess, deficiency, or derangement of it causes corresponding derangement in living bodies. As the integrity of specific atomic relation is essential to the identity and preservation of all beings, so the natural integrity of electrical equilibrium cannot be broken, or have its balance long disturbed, without an equal disturbance in all the functions influenced by definite electrical agency.

That, as we are taught by experience, some people are scarcely liable at all to impulses of galvanic inequality; some are very slightly so and others slowly affected, or only after long intervals. We have also seen, that some persons escape altogether the shocks or oscillations of galvanic passes; others slightly feel their premonitory signs, or symptoms; whilst some withstand the concussions or derangements for weeks, or months. I cannot believe that similar differences would result, were marsh miasms, or poisons, (inhaled by breath,) the exciting cause; such active poisons, if in existence, and capable of destroying strong men in a few hours, would bring every human being within their reach under their destructive sway, without omission or delay.

That as free electricity very generally prevails in the air of most places, it may be asked, why *cholera* in man, and *blight* in vegetables, do not commonly prevail at all times. To this I reply, that the integuments, even of delicate human beings, are not susceptible of ordinary or slight electric passes, unless the part be moistened. The whole surface becomes moistened in hot climates by the dew at night; and hence I think that cholera or agues *invade* people at night, particularly towards morning; as we know that negative electricity reduces men in the rice lands of Italy to the most awful state of disorder. But were the cause, as said to be, miasms, extracted from fens by the heat of the sun, their lethal violence would, on the contrary, assail all persons by day. As multitudes labor in the fields by day, multitudes would fall by poison; but thousands escape the pest, *provided* they do not sleep in the air, or on any ground floor by night.

That I believe to produce certain grades of epidemics, certain stages of galvanic disturbance must be in operation. But it is seldom that such rates of derangement traverse the atmosphere or globe; consequently, we have not cholera or intermittents in all places, or at all times; although electricity, at rest or in motion, may be variable or disturbed, to a certain extent, in every situation. As we reach *definite* degrees of heat, to boil water, or to freeze it, we must contend with a *definite* degree of disturbance in galvanic force, fit to inflict epidemic catarrh, and a different definite point, sufficient to occasion epidemic cholera.

That the latent galvanic equivalents in living things are seldom so much deranged as to damage the laws of life; mild degrees in the scale of disturbance inflict only mild corresponding ailments. Were we to assume, by way of illustration, a symbol of figurative quantity, as the neutral, latent, or natural equivalent of atomic electricity in a man, and state the standard amount [say] at ten thousand, or any other number of equivalents, then we might infer, that if ten degrees be added, abstracted, or *disturbed*, some local epidemic would result to persons similarly struck in that situation at the same time. As the cause (only ten degrees) is not considerable in this supposed case, so the effects will be mild in proportion. Periodical and nocturnal returns of old pains, nervous complaints, neuralgia, or nightly rheumatism, would probably be the symptoms of disorders corresponding to such points of definite or atomic galvanic alteration.

That when the east wind (almost always passively electrified) prevails; when stagnant rivers, ponds, sewers, cesspools, filthy streets, and drains, fens, or marshes, fed by changes of decomposing matters, create *galvanic troughs* of great extent and active energy; when their *intense* emanations flow in currents, and are linked to people by electric chains of vapor, damp air, wet floors, or filthy garments, — then, as the disturbing forces are severe, the loss of electric balance is severe also. Should the derangement of the balance amount to forty, fifty, or sixty degrees, out of the normal quantity, these points will correspond with the ratio of broken balance which may stand in relation to catarrh, epidemic influenza, diarrhœa, dysentery, fevers, and other local epidemics, similar in character under similar circumstances.

That, when millions on millions of horse power of galvanic forces are hourly evolved in the sultry morasses and festering deltas of the hot east; when strata after strata of our globe are daily galvanized, by communication or induction; when miles of excited earth transfer conduction to adjoining miles; when electric wave follows wave, flowing round in a zone of resistless disturbance; when a belt of such stupendous streams of untoward galvanism encircles the earth itself, which is the great source and reservoir of electricity, — then it is no wonder that plants, fishes, birds, beasts, and men, placed over such an electrified girdle of the globe, should suffer, each according to their susceptibility and organization, and to the extent or continuance of oscillating currents. A hoop, or circumference, broader than the peninsula of

India, conveying long-continued electric concussions and steam-electricity under land and water, will carry the disturbing range to eighty, ninety, or one hundred degrees, every series pointing to different series of disorders.

That there is reason to believe, a disturbed cincture arrives and retires with the revolutions of this planet. Perhaps the time may come, when the dreaded advent of these revolving sources of disturbance may be predicted by calculation, as the march of the cholera was estimated, in 1832, at the rate of about ninety miles per month. It is, therefore, when the excited air above, and the exhausted earth below, attract and repel long interchanges of galvanic emanations, that greater or more dangerous pathological degrees of disturbance ensue, fit to derange the scale to the point of such vast loss of balance as to indicate the exciting causes of typhus fever, sweating sickness, bubo plague, yellow fever, black vomit, and black death.

Within and around our cities and towns we contrive the most extensive batteries for extricating galvanism; we establish currents and counter currents of the electric [fluid], and of its *vehicles*; viz., the noisome gases, escaping up our pipes and drains. These foul airs rush up into our apartments, conducted by walls and floors, and carrying up currents of overpowering galvanic emanations. The walls and atmosphere of the rooms, being, in general, positively charged, induce negative passes from the human bodies within their range, and from the moist earth below attracting the electricity of the persons present, if of an opposite, and repelling it if of the same kind.

These results led to the conclusions which were afterwards confirmed by more extended researches in Italy. I found that when human beings recline upon moist ground, or on beds placed upon it, their *natural*, latent, or neutral electricity is disturbed or decomposed by the extensive surface of the body exposed to telluric attraction and repulsion of galvanic currents, conducted by the fatal chains of damp walls or floors, stagnant drains, filthy beds, or soiled clothing.

In the places described, extensive evaporation, and energetic chemical action during the day, charged the atmosphere of the place with positive galvanic fluid. This surcharge passed through the moist conducting bodies of the people into the earth, attracting their negative and repelling their positive electricity. Again, when, during the diminution of the electric fluid of the air, before sunrise and sunset, the effervescing earth transmitted its excess upwards, through the persons so exposed, the neutral (fluid) in their bodies was disturbed, or the positive (fluid) was attracted to one side or extremity of the bodies, and the negative fluid repelled to the other side, and thus a process of attraction or repulsion exerted untoward oscillation in the bodies, brain, and spinal cord, and felt in particular, in the great sympathetic system.

In fine, we must conclude, that we are always under more or less *electric tension*, as the air is naturally positive, while the surface of the ground, together with all objects upon it, are in

a preponderating negative state. It is, indeed, a matter of general observation, that this tension, or disturbed electrical condition of the atmosphere, whether it chances to be plus or minus, positive or negative, actually causes the more sensitive persons to feel otherwise unaccountably uncomfortable — sometimes as if all things were more than usually heavy, hard, noisy, or tiresome; at other times, they are irresistibly irritable, excited, or restless; at others, perhaps, depressed or melancholic. When the atmospheric electric deficiency is sudden and great, there is produced in nearly all persons, even in those in health, a certain mental depression, oppressive yawning, or uncomfortable feeling of gloom or discouragement. While a rapidly prevailing *surcharged* air, particularly if chafed by high, dry, and protracted winds, produces not only nervous irritation, unrest, and epidemic influenza, or prevalent colds, but even prevailing inflammatory diseases; at the same time rendering a large portion of the sick, and persons with morbid nerves, worse; while another large class of maladies and temperaments are as much benefited by it. So sure as autumn brings the blessing of harvest, and with that harvest also cholera infantum, epidemic dysentery, intermittent and bilious fevers, so sure will any considerable atmospheric electrical changes awaken all manner of painful affections. Repeated observation has made the author quite familiar with the coincidence of the prevalence of violent attacks of neuralgia, during, *or soon after*, the more brilliant displays of the electric and magnetic flashes of the aurora borealis.

# CHAPTER II.

## EARLY HISTORY OF MEDICAL ELECTRICITY.

### *History of the Medical Uses of Static Electricity.*

Our place is in the *new world*, our time in a *new age*. If we trace back but a little over one century, we shall find that medical electricity was a new theme, and formed but a short, undefined, and hence unimportant chapter in those works of systematic writers that treated of Therapeutics. The Leyden jar was then but just discovered; the physiological effects of the electric spark and shock were only surmised. Our Dr. Franklin had not demonstrated to the world the actual identity between the lightning of the clouds and the electricity produced by friction. But one hundred and fifty years ago and electricity developed from rubbing smooth pieces of wax and glass was the theme of universal wonder, and of scientific investigation. The astonishing powers, laws, and works of galvanism were utterly unsuspected. The relations of electricity to magnetism, and *vice versa*, remained yet hidden from the eyes of science for a long half century. Can we truly realize that water was then supposed by all the learned world to be a simple substance; that the laws of heat were unknown; that even the philosophers of 1760 did not dream of electricity as being the very *key* to physiology; to molecular physics, and hence to metaphysics; for penetrating and revealing the intimate structure, relation, and nature of bodies; that chemistry would be indebted to its subtile power for nice analysis and synthesis; for elucidating theories, and for forming entirely new compounds; that the physiologist would have deduced by its aid a most intimate knowledge of, and familiarity with, those innate forces that, hand in hand

with *vitality*, rule over living bodies, and are next to the very mainspring of life itself; and finally, that the physician and surgeon would find in it a very peculiar power for healing, and restoring from a class of diseases that baffled all skill, and were considered incurable? One hundred years before that, and it has been well said, that Newton was a schoolboy. Gravitation, or a code of laws for the universe, was unthought of. The globe had not been weighed as in a balançe, nor had the true figure of the earth been recognized. Of course the "Principia" and the "Optics" of Sir Isaac Newton were as yet unwritten. Electricity and magnetism were scarcely acknowledged as sciences. Philosophers were speculating on their properties and their importance, but they never obtained a control over them. Can we realize, that but one hundred years before that, and we plunge into the very abyss of the *dark ages?* where, not only medicine and the physical sciences that relate to the healing art, but also all the physical sciences, were sleeping, as they had done for a long thousand years before? Without recounting our own otherwise untold inheritance of religious and social treasures, what rich *legacies* of chemistry, botany, geology, geography, mathematics, mechanics, physiology, electricity, and electro-magnetism were laying in stores for these generations then unborn! But over what was then known there lay a ponderous mass of dogmatic *theories*. No free discussion, no subject for dissection, no correct idea of the work of the lungs, or of the heart; no microscope, no barometer, or thermometer was heard of. In science there was as yet no minutiæ, or *speciality;* it was only at the risk of life that any new thought, or even any ascertained fact, was then given to the world. But now we come to an age that has both the facilities and the inducements for that minute and scrupulous observation, that discovers to us by the aid of inductive philosophy, as it were, new continents in science, inviting us to labor and usefulness. Such are the indissoluble links that bind electricity with physiology, and also with the whole science and art of medicine, that a more intimate study of it, in these relations at least, has become quite indispensable to all medical men of the present day. In therapeu-

tics the march of discovery is continually going on. Entirely new paths are opened; new methods of research, and of doing things, new instruments to facilitate the work, new laws are evolved, giving connection and combination of facts and phenomena which are unceasingly and increasingly accumulating around us. The discoveries of M. Matteucci, and of Dubois-Reymond have demonstrated to the equal astonishment and admiration of the present age, the curious, exquisite, and subtile relations which exist between voltaic electricity and the natural *functions* of nerves and muscles, not by any means proving the absolute identity of the nervous element of force with electricity, as some claim, but approximating a view that solves facts beyond all previous expectation. But who is able, after all, to discuss the actual relations of vital to physical forces, as applied especially to the human organism? Greater still would be the folly to plunge here into the depths of that still more abstruse question of the proximate relation of matter to mind, or into the domain of physical causes — to the total phenomena of animal life! None of this can occupy our time or space.

First, I wish to quote an account which has been given of the first shock of electricity, which electricity was accumulated, and then administered to the human body, by any explorer in this particular field of science. The simple story shows the utter astonishment that followed the effects. The historian says, "The end of the year 1745 and the beginning of the year 1746 were rendered famous by the discovery of the *accumulation* of electricity on glass, called the *Leyden vial*, so called because the experiment was made by a native of Leyden, Mr. Cuneres. But the person who made the discovery of the phenomenon was a Mr. Von Kleest, the dean of Cammin. On the 4th of November, 1745, the first electric shock was felt by this gentleman."

He says, when a nail, or a piece of thick brass wire, is put into an apothecary's glass vial, and this is electrified, then very remarkable effects do follow. Mr. Muschenbroek tried the experiment with a very thin glass bowl, and says in a letter to M. Reaumur, that he felt himself struck in his arms, shoulder, and breast, so that he lost his breath; and it was two days before he

recovered from the effects of the blow and terror; and that he would not take a second shock for the kingdom of France. Various accounts are given of the effects of such shocks, repeated by different persons in different places about those times; but we have space only for those of M. Winckle, of Leipsic. He says that "the first trial of the *Leyden experiment* produced great convulsions in his body; that it put his blood into such a state of great agitation that he was for a time afraid of an ardent fever, and was obliged to use refrigerent medicines; that he felt a heaviness in his head as if a great stone lay upon it. Twice it gave him a bleeding from the nose. His wife was the first woman who had the courage to try a shock, and from this she found herself so weak that she could hardly walk." Such were the first rude and rash experiments made with dynamic electricity on the human body by *shock;* but *sparks* were employed even before that; also for remedial purposes. M. Kratzenstein, a German physician, was the first to record, in 1744, a methodical treatment and cure, which was a case of paralysis of the fingers, cured by sparks drawn from the then common electrical machine. Next we find "A Treatise on the Effects of Electricity upon the living Human Body," by M. Jallabert, which was published in 1748. He sums up the most general phenomena observed from the application of electricity as follows: First, an acceleration of the pulse; second, an increase in the warmth of the part; and third, involuntary contractions actually produced in palsied muscles. This, we take it, must have been the first work on electro-therapeutics. Small as were the resources, and few the beneficial results, yet the then medical world did not let the matter rest, for the Abbé Sans, in 1772, published a work on medical electricity, in which are found reported the treatment of eight cases of paralysis, some cured and others very much benefited by the sparks and shocks, which was all that was known of electricity up to that time.

The most important works and monographs relating to Physiological and Medical Electricity that have come under our observation, are those of Sauvages, of Montpellier, in 1749; L. Spengler, of Copenhagen, in 1754; Le-Roy, of Paris, in 1766;

Benjamin Franklin, in 1760; J. Wesley, of London, 1760; J. G. Schöffer, in 1766; J. G. Hartman, of Hanover, in 1770; L'abbé Sans, in 1771; Sigaud de La Fond, of Paris, published several works from 1771 to 1803; Encyclopédie de Diderot et d'Alembert, in 1777–8; Tibere Cavallo, of London, in 1777; L'abbé Bertholon, in 1780; Mazars de Cazeles, of Montpellier, in 1780–92; Bonnefoy, of Lyons, in 1783; C. W. Hufeland, of Gottingen, in 1783; Fowler, of Edinburgh, in 1783; K. G. Kuhn, of Leipsic, in 1785; Manduyt, of Paris, in 1785; W. Van Barneveldt, of Amsterdam, in 1785; Galvani, of Italy, in 1791; Valli, of Italy, in 1793; Aldini, in 1795–1804; works of Pfaff, Hufeland, and G. C. Morgan, of Geneva, in 1798; Alexander von Humboldt, in 1799; a work by Grapengiesser, of Berlin, in 1803; F. H. Martens, of Leipsic, in 1803; works by Ritter, and by Erman, of Germany, in 1808; A. Volta, of Florence, in 1816; Alibert, in 1817; Dr. Mansford, of England, on Electricity for the Cure of Epilepsy, in 1818; G. F. Most, of Lunenburg, in 1823; M. Girardin, of Paris, in 1823; MM. Provost et Dumas, of France, in 1823; Meissner, in 1825; M. Magendie, in 1826; M. Nobili, in 1827–34; Labaum, published in London, in 1828; M. Marianini, in 1829–34; Andrall et Ratier, in 1831; Dr. F. Palaprat, in 1833; Graves, of London, in 1835; J. F. Condret, in 1837; M. Galtier, in 1839; Dr. Prosch, of Hamburg, in 1845; Julius Regnault, in 1847; M. Matteucci, on Electro-physiology, in 1844; Emil Du Bois-Reymond, from 1843 to 1848–9; the works of Sarlandière, Alexander Dumas, J. Cloquet, and Leroy d'Etioles, that appeared about 1842; Golding Bird, of London, in 1850; M. Martinet, and M. J. Massé, in 1850; M. Duchenne, of Boulogne, from 1852 to 1860; R. Froriep, of Berlin, in 1850; W. F. Channing, of Boston, Massachusetts, in 1852; M. Eckhard, in 1853; a work by A. De la Rive, in two volumes, in 1854; Robert Remak, of Berlin, in 1856; M. Briquet, in 1859; M. van Holsbeck, in 1860; Middeldropff, of Berlin, in 1856; M. Becquerel, of Paris, in 1859; M. Gavarret, in 1858; J. Altheus, of London, in 1860–64. More or less recently are the very important works of Fechner, Schröder, E. Pfluger, Rosenthal, Otto Funke, Helne, Meissner, Hyr-

tle, Valentin, Kolliker, C. Bernard, Brown-Sequard, Léstor, Bonnet, Amusatt, Dr. Gull, Spencer Wells, Bence Jones, and Radcliff, of London.

There are some other less important works found, that were published in the latter part of the last century, upon this branch of medicine; but they are not of value to be recorded here, excepting, perhaps, by allusion to one or two, to show the toleration of those most ridiculous notions which prevailed up to those times in all departments of regular medical practice. Signor Pinati, of Venice, introduced Peruvian balsams and a variety of other medicinal substances into the glass cylinders of the different electrical machines he employed for the different classes of diseases. One Dr. Giuseppi Bruni employed in the cylinder of the frictional machine, with which he operated, certain purgative medicines, and the patient, after having been thus electrified, (sic,) is said to have experienced the same effects as if he had swallowed the medicine!

However, the frictional machine has always found a place in the armamentarium of therapeutics to the present day, although very much less since Faraday discovered the *induction current* in 1831. Within and during the last fifteen years, static electricity has been considerably employed and made to accomplish some very wonderful cures in the electrical room of Guy's Hospital, in London, through the perseverance and skill of the celebrated Dr. Golding Bird; also, with and after him, by Dr. Gull, accurate accounts of which are found scattered along year by year in the voluminous reports of that noble and excellent institution.

As a matter of history, for the actual starting point in this branch of medicine, we must go back for more than two thousand years, even to the days of the great philosopher, Thales of Miletus, who ranked as one of the seven wise men of Greece — to him who founded the Ionic sect. It was he who first mentioned electricity as a remedial agent, some five hundred and forty-eight years before Christ. He also taught his pupils that electrized amber possessed a soul.

*Lightning of the Clouds* was first demonstrated in America. Franklin, a Massachusetts man, proved that it was electricity. This seemed to be the key note for awaking an age of improvement. Electricity, in its various manifestations, now some hundred years after that event, is studied by thousands, and manipulated by tens of thousands, the world over. Every where now it is harnessed for errands, for nice chemical and mechanical work, for science, and for healing. Yet it is only a little over a quarter of a century since we have become familiar with any one department of its operations. During a space of seventy years, i. e., from 1760 to 1830, experiments, conjectures, and theories were plenty enough. That it was a power no one doubted; but what to do with this unique agent no one could tell. Who should discover for it a bridle or a yoke? Well, the world had to wait many years for a Galvani, a Volta, for Humboldt, Nobili, and Arago; for a Henry, Faraday, Whithouse, and Morse; and in the physiological and medical department, for a Matteucci, Dubois-Reymond, Becquerel, Pfluger, Duchenne, Remak, and many more illustrious names. So that now, fear, superstition, and prejudice are nearly overcome, and we may reasonably expect more tangible progress to take the place of the early, vague, and extravagant predictions.

In the Library of the Academy of Sciences in Boston, in the Athenæum building, on Beacon Street, are the original notes and correspondence of our own native philosopher Benjamin Franklin — papers prepared while making his original experiments with friction and atmospheric electricity. These date from 1758 to about twenty years thereafter. His extensive correspondence with the very learned persons and accredited philosophers of England and other countries of Europe, showing the status of their respective experience, and their opinions at that time, their discussions, prophecies, and embryotic theories, are thus mostly preserved in documents and binding. *The lightning rod* was the invention of Franklin. Beyond this, curious electric phenomena, electric laws of action on various substances, improvements in friction apparatus, and in their manipulation, together with a simple outline and hint of telegraphing, appear to have

been the main points attained. We find nowhere there any true rule or law for the use of electricity as a therapeutic. From want of apparatus and experience, only "being charged with *aura* until the hair stood up," or "*electrized by shock*," was practised by him, and others abroad.

In the earlier periods of philosophical research, when the acquisition of knowledge was less tested by accurate and repeated experiment than it is in this present sharp age, impositions, superstitions, and dogmatic theories persistently prevailed, so as to render electro-physiological and therapeutical progress all but impossible. For instance, it was asserted to have been demonstrated by Dr. Winckler, of Leipsic, in Germany, that odoriferous medicines confined in stout glass vessels, when excited by electricity, would, by that excitation, not only diffuse their odors, but their magic medical virtues, through the glass and contiguous air, and so communicate health to those within their reach! Such were some of the early medical uses and expectations of electricity.

In this country, during all that time, electric machines were becoming more and more in use for experiment and for public amusement. If electricity was suggested by the medical attendant for a case, say of rheumatism or palsy, the proposition was usually met with, "We have tried it, and it did no good." Some might well say "they had tried it, and were injured by it." If such were asked who administered it, and how it was done, they probably would answer that "*they were electrized at the museum*," or "*on training day*," or "*by a travelling lecturer*," or perhaps the squire or the schoolmaster had a machine, and "they went over there and *took a shock*." But how it was given, that is, which way the electric current passed, &c., no one knew. One thing was known, and remembered well, and that was, that "the shock was very severe; enough to almost dislocate the joints, or to knock the subject down; and his mind was made up *never to be electrized again*."

Taints of this old prejudice, as if inherited, or very instinct, are visible at the present day; for but few of our younger and middle-aged people ever "*took a shock*" after the olden style.

At least, no teacher in college, no respectable schoolmaster, in these enlightened days, should tolerate such trifling with electricity and nerves. Not only terror is liable to be impressed upon the mind, but absolute injury is often stamped upon the nervous constitution of the delicate young and impressible subjects, that will be echoed in after years, in back-aches, headaches, neuralgia, or nervous debility. Lightning may chance to kill or cure; so may abusive random use of electricity produce permanent injury.

Hence, is it to be wondered that treatments, statements, and circumstances of this sort should have retarded electro-medical science, and even produced the disgust of public opinion, or excited the ridicule of sober inquiry? Moreover, we see that this mighty agent for good or evil has been too much and too long yielded into the hands of the superstitious and ignorant, the designing empiric and quack.

Thus at first, and for a long weary century, this, like some other discoveries of vast importance to mankind, had well nigh been lost to medical science, or at least rendered of little value: first, from the accidents of different methods of experimenting, which nearly neutralized the results of master minds; second, from quackery and empiricism; third, from the overrated and extravagant eulogisms. Facts which, in their simple native dress, ought to have led to early deductions so highly useful, were distorted by exaggerated representations, by accidental misunderstandings, and by medical sectarianism, which created for *the subtile agent* discredit, disgust, and neglect.

In this country, as early as 1816, Dr. Thomas Brown, of Albany, New York, practised "*medical-electricity*," using the older style cylinder machine, "drawing the healing power from the ambient air." To this point we trace the first step in advance of the terrible *shock*. He invented and patented a modified machine and leydén-jars, "for giving electricity *in a mild way*, by small sparks, and in a continuous stream," for a portion of an hour at a time. He also published a little book in 1817, entitled "*The Ethereal Physician*." He appears to have "cured cases of tic douloureux, king's evil, dropsy, nervous palsy, numb-

palsy, epilepsy, hysteria, amenorrhœa, headache, crick-in-the-back, rheumatism, and St. Vitus' dance." He seems to have been most successful in "curing *night rheumatism*," or "those cases that are most painful when still." He says he treated and "cured headaches *by electrifying from the head down towards the feet*, once in a while; for so true is that belief and saying of Franklin, 'the *way* the shocks are directed (for in his day it was all *shock*) they cause the blood to flow.'" This electro-medical practice of Dr. Brown received the commendation of the excellent S. M. Mitchell, M. D., T. Romeyn Beck, M. D., Joseph Parish, M. D., Thomas Jefferson, and others.

In 1818 Dr. Jesse Everett was practising "medical electricity" in the city of New York. He used the improved friction machine and jars patented by Dr. Brown. For many years he appears to have been looked up to as the *great medical electrician* in this country, and receiving the cordial approval of Richard Kissam, M. D., and nearly the whole medical faculty of those days. In a small book published by him in 1823, he says, "As an act of justice I must here mention the patronage and encouragement of professional gentlemen generally. They *prescribe* the use of electricity as they would any other appropriate remedy; and then describe the situation of the patient to me, and leave it to my experience and observation to *direct* the application of electricity as I thought would be most beneficial. The older physicians and surgeons have generally pursued this course, which has rendered the intercourse agreeable to all parties, and they say uniformly beneficial to the patients. But some of the younger practitioners have occasionally tried to give me instructions, which has more often betrayed their vanity, without affording me any useful aid or information."

A venerable Quaker, residing at Skeneateles, Onondaga county, N. Y., having, a long time before, experienced the good and lasting effects of electric treatment "for a partial palsy, with a bad humor and dropsy," thus wrote, on the 22d of August, 1818, to Dr. Benjamin Tucker, medical electrician, 324 Market Street, Philadelphia: "Respected friend, — Through all the changing scenes of this life, one thing has not altered, yea, two — my

regard for thee, and my high estimation of thy *Heavenly Medicine.*" This letter was written over thirteen years after the said treatment and cure.

The medical use of electricity, by means of improved *friction* machines, we find frequent accounts of as late as 1820; and those regular medical practitioners particularly skilled in its use were counted regular electricians with no diminished honor; much in the same sense that medical men now, throughout the country, who may be peculiarly skilled in surgery, are also called surgeons. This title of "*medical electrician,*" if the person was a good practitioner, was understood as synonymous with the title of *physician-philosopher.*

Friction electricity was repeatedly looked to, by medical men of those times, as an important agent for stimulating the activity of the *secreting organs* in various difficult chronic maladies. We have evidence of its quickening the capillary circulation of the skin, and inducing perspiration; of which, indeed, any one, whose skin is not absolutely dry and harsh, may convince himself, by sitting on an insulating chair, and connecting himself with the prime conductor of a good cylinder or plate machine in full action for ten or fifteen minutes. So, also, will this electricity act on the absorbents, and with them quicken the deeper capillary action. Dr. Franklin and others testified, that in many cases they observed the most unquestionable evidence of its peculiar activity and value; as in chronic rheumatic effusions into joints, provided the effusion was perfectly fluid, and not too old. Thus success was obtained by placing the patient in an insulating chair, connecting him with the prime conductor of an electrifying machine, (*in a dry atmosphere,*) and drawing strong sparks from the joint, until the skin became red and patulated, and the patient was in a general perspiration.

### *History of the Discovery and Medical Uses of Galvanism.*

Galvanism, as is now well known, was discovered and demonstrated by Professor Luigi Galvani, of Bologna, in 1786, although he did not publish his discovery and commentary "*De Viribus*

*Electricitatis in Motu Musculari*" until 1791. In that work he laid down the proposition that there is a peculiar form or kind of electricity existing in all living animals, which he designated as *animal electricity*. As to his famous discovery, by means of the contractions of the legs of a dead frog, he believed that he merely *excited* and rendered sensible this native electricity by covering a nerve and a muscle with metallic conductors, but did not regard the latter as the real source of the electricity. In fact, Galvani based the explanation of the phenomena of muscle contractions on his *neuro-electric theory*. He assumed that all animals are endowed with an inherent electricity, exactly appropriate to their economy, which nerve-electricity, being secreted by the brain, resides mostly in the nerves, and by which it is communicated to every part of the body. The principal reservoirs of this electricity he considered to be in the fibres of the muscles, each of which he regarded as having two sides, i. e., opposite electric conditions. He believed, therefore, that when a muscle was *willed* to move, the nerves, aided by the brain, drew from the interior of the muscles some electricity; then, by discharging this upon their surface, which he believed to be negative, they were made to contract or draw together, and thus produce the required change of position. Thus, then, Galvani was the first not only to stumble upon the manifestation of a new form of electricity by the frog twitchings, but to blindly demonstrate *the existence of animal electricity;* for he verily thought it was that only which produced the phenomena. Here were given to the world two stupendous truths, by a single little prophetic fact! When he touched the sciatic nerve of a frog with one kind of metal, and at the same time touched the muscles of the leg with another kind of metal, while the other ends of the two bits of metal were in contact so as to form an arc, there was observed a sudden contraction of that leg of the recently killed frog; and this he interpreted as only evidence of an excitation of the peculiar electricity that was in the nerve and leg of the frog. He evidently did not comprehend that he had before him *two discoveries* in the one first experiment; that he was in fact demonstrating most clearly what we now know as galvanism, while

it was not so clear an evidence of animal electricity, but which was in fact equally as true.

It is said that Dr. Galvani, at that time Professor of Anatomy at Bologna, had his attention first drawn to an accidental and strange phenomenon by one of the medical students, that ultimately led him to the discovery of galvanism. Some frogs had just been dressed for a soup for Madame Galvani, who was an invalid, and hung along suspended by copper hooks connected to an iron railing. The student observed, that as these frogs' legs were moved by the wind, or other cause, so as to touch a lower part of the iron grating, they would at the same instant become "*convulsed*," and exhibit a peculiar twitching movement, which was repeated at every fresh contact, as if still alive. Dr. Galvani immediately commenced a series of experiments, to which he devoted himself almost exclusively for years, producing the same phenomenon in a more and more marked degree, by employing the legs of very recently killed frogs, and the application of certain metals both to the *nerve* and the *muscle* of the mutilated animals.

Fig. 3.

Shortly after the announcement of this discovery by Professor Galvani, this marvellous experiment was repeated by various scientific men in Europe, as well as in this country, as a curious circumstance. It appears that Galvani repeated and varied his experiments on the legs and nerves of the mutilated frog, again and again, for five successive years, before he put forth to the world *the fact*, and his explanation of it. But the very next year after the publication of this wonder of that day, Professor Volta, of Pavia, having set himself at once to the repeating this and other analogous experiments, publicly declared that he had arrived at a new and different conclusion as an explanation of the twitchings of the legs of the recently killed frog. He showed that the electricity was elicited *from the contact of two dissimilar metals*, while the contraction of the muscles of the frog was only an index of its existence. This explanation of Volta contained also substantial and important truth; but, from the heat

of the discussion, or from his peculiar disposition, notwithstanding his masterly learning and unquestioned ability, he could not see, or would not admit, the co-existing truth of his contemporary's theory of *animal electricity*. He utterly denied the existence of any sort of animal electricity, while he demonstrated that the arc of two different metals was the origin and cause of the electricity, and of the new wonder. And here were the germs of two stupendous discoveries; at first so apparently small as to be insignificant, and so imperfect and contradictory as to appear worthless, yet two fundamental laws in nature, — *animal electricity* and *galvanism* — with which mankind will ever after have much and still more and more to do.

A very sharp and protracted discussion arose between Galvani and Volta, and their respective partisans in all countries, in respect to *the first and sole cause* of the contractions produced by given means in the legs of the frog. Galvani persisted in assuming the existence of an animal electricity, which he believed to be *positive* on the surface of each muscle, while the negative electricity was condensed in the interior or body of the muscle, much as it can be in a Leyden jar, and that the nerves serve merely as conductors between the two coatings of this living species of Leyden jar. What a paradox! Yet, years afterwards, when Sir Charles Bell had discovered and pointed out the difference between the motory and sensory nerves, as being true in anatomy, this long doubted and even scouted idea of Galvani was seen and acknowledged to be not so far from the truth. But in those days, as we have said, Volta made it appear most conclusively that the electricity developed and manifested so curiously, was merely from the *contact* of two heterogeneous metals; and what confirmed this opinion was the simultaneous discovery of the power of the *pile* by Professor Volta; the construction of which was his own invention, but after all it was only the suggestion of Galvani's experiment, which was so doggedly opposed by M. Volta. Professor Galvani demonstrated, the next year after, that this contraction could be produced in the frog also by means of an arc or conductor of but one kind and piece of metal, or even without employing any kind of metal at all.

To make this fair and clear, Galvani would take a frog and first kill it; then quickly skin it; and then, by passing the point of a pair of sharp scissors *beneath* the two visible and easily accessible lumbar nerves, which always lie, as can be seen, by opening the abdomen of a frog and pressing the entrails to one side, as they naturally lie superficial for a half inch upon the psoas muscle and anterior to the vertebral column, so that the blades of the scissors embrace all the loins except the nerves; he then cuts again in the same manner a half inch above or below, so as to remove the two or three lower vertebræ, and leave the nerves intact and uninjured, but separate, reaching from the thighs to the body of the frog, suspended in the air like telegraph wires. He would then touch a nerve with one metal, and the muscle of the thigh by another metal, and then, when the outer end of these two metals touched, i. e., were in contact so as to form an arc from nerve to muscle, there was an instant powerful contraction. But as Volta objected, on account of the two metals employed, Galvani used a bit of wire of but one metal, one end of which touched the nerve, while the other was made to touch the muscle, and by this the same instantaneous contraction was produced, *but in less degree*. But Volta again objected, that however infinitesimal might be the conceivable difference in the homogeneity of the metal arc used for the conductor, it would be sufficient to produce an electric current that might be made perceivable by the delicate test of the contractions of the frog's leg; for this was indeed not only the most delicate test of electric currents, but it was the only galvanometer then known.

M. Galvani then attempted to produce the contractions without the employment of any sort of metal, or other foreign substance whatever. He therefore cut off the body from the projecting lumbar nerves, and then let the nerve fall upon the plate of glass upon which several such cut-off legs and nerves lay. He then would raise the nerve carefully with a small glass rod, and bring near and under it another frog's leg, and then let the raised nerve fall or touch gently but a single point on the external surface of the muscle; and this even produced contrac-

tions instantly and exactly as before, with the exception that they were more feeble even than in the second series of experiments, which was done by one metal. So conclusive was this final result, when the experiment was carefully done, that there was not a word left for reply by any convincible man; yet we find that Volta as persistently denied that final and grand result. By his great learning and masterly skill, he convinced or silenced the learned men of the world mostly, so that the prevailing public opinion settled down upon Volta's views, until he and his generation had mostly passed away.

Among those many who took a deep interest in this all-absorbing discussion of those times was Alexander von Humboldt; and before that century was closed, he had bestowed so much time and labor on these and other similar experiments, that he put forth unanswerable explanations that showed that those philosophers, Galvani and Volta, *were both right in the main*, but were in some respects wrong, and that here lay the cause of their difference. Baron Humboldt's conclusions were concurred in by Hufeland, Pfaff, and other distinguished German philosophers and physicians, who strongly urged the propriety and importance of searching for the best modes of employing electricity as a rational therapeutic agent, although they did not claim to have employed it themselves, except in their various experiments. These researches of Baron Humboldt were published in 1797, which in themselves show how ardently and thoroughly he went into this work, not failing to subject his own precious body to the corrosive action of metals which were applied immediately to purposely denuded and raw surfaces, as if to signify the greatness and sacredness of the subject he was determined to solve. He then explained and maintained the original views of Galvani, and gave him all praise for the patience and indomitable perseverance that so conclusively demonstrated the law of nature, viz., *animal electricity*; and at the same time offering such reasonable explanations, and yielding such praise for the discovery of the *voltaic pile*, that should have entirely reconciled those two Italian philosophers and their respective partisans. In 1799 Humboldt set out for his American travels, and

thus left the sway of creed to prevail with the Voltaic theory for the then thirty years to come.

Great novelty and furor attended the vast discoveries which were so constantly being made on the constitution of *inorganic matter*, by the aid of the truly magic pile of Volta, which was every day being modified, and in time greatly improved, so that a power was made available, that in the hands of Sir Humphry Davy, resolved many bodies, previously considered simple, into their constituent elements; and this quite changed both the nomenclature and the denominations of chemistry, creating as it were a new era in that department of science. Not only so, but still more recent, in the hands of England's Faraday, has it led to the actual discovery of new sciences, and of properties of matter before not dreamed of.

But in the mean time, the very curious phenomena observed in the frog could not be entirely forgotten, or neglected, by all the thoughtful and sagacious. Signor Valli, an Italian physician of great celebrity, commenced his researches as early as 1792, which was only one year after Galvani published his discovery, and *neuro-electric theory*. Dr. Valli believed the neuro-electric *fluid* to be secreted by the capillary arteries which supply the nerves, by which this fluid or *ether* became conveyed to the muscles,—which he believed to be always in an electric condition,—the interior being negative, while the exterior is positive. He also put forth the fact, that in experimenting on frogs, the nerves lose their irritability to the stimulus of electricity, *first at their origin or trunk*, but retaining it longer at their periphery or extremities. Upon this fact he hazarded the opinion, that probably "the distal extremities of nerves are the true origin of these structures." It is said of him that he was the first to form a battery or pile of some fourteen prepared frog thighs, and obtained thereby evidences of a true galvanic current. He publicly defended by demonstrations the almost obscured views of Galvani, by cutting the lumbar nerves of frogs high or near their exit from the vertebral canal, so as to leave them as long as could be, and then, raising them as delicately as possible with a glass rod, so as to touch a piece of any recent

muscle, such as cut from the flank of another frog, placed in a watch-glass in such a manner as to have no sort of connection with the frog, and thus he produced marked contractions. He also publicly repeated, from year to year, another of Galvani's experiments, which was to place on an insulating plane, or two separate planes of glass or wax, two separate thighs of a frog, prepared with long, projecting ischiatic nerves, which he bent into a semicircle on the cut end of the thighs, and then brought them together so that only the tips of the two nerves came in contact, when at that instant the two legs contracted energetically. But these results were doubtfully received by the learned world, notwithstanding the then young Baron von Humboldt advocated Galvani's and Valli's side of the question.

The most celebrated of the early treatises on medical galvanism was by Professor Aldini, of Bologna.* He states that he applied a very powerful current from a voltaic pile of some hundreds of pairs through his own head just above his ears, which so excited him that he continued sleepless for several days. He conceived that this treatment would be of service for that class of the insane who are melancholic, and relates the treatment of two cases that were actually cured by this means. He speaks of the great inconvenience of the voltaic pile, from its inconstant current, as well as expense and trouble. But before he published this work, he travelled over Europe, even through France and England, demonstrating and defending the theory of his illustrious uncle Galvani. It is evident that Professor Aldini's propositions and conclusions were of a high order and interest, since it is recorded of him, that when in London he appeared before the medical officers and pupils of Guy's Hospital in 1803, and there supported and defended a series of propositions so satisfactorily and conclusively, that he was presented by his auditors with a gold medal, commemorative of his labors. Besides, on leaving England, his propositions, together with the arguments in support of them, were prepared and published in a quarto volume, which, however, attracted so little attention,

* Essai theroique et experimental sur la Galvanisme. Bologne, 1804.

that in 1847, Dr. Golding Bird says, "I found the copy in the library of the Royal Medical and Chirurgical Society with the leaves uncut." I wish to make a record here of these early propositions of Aldini, because they so remarkably corroborate, as they evidently did also anticipate, the late brilliant researches of his countryman, Professor Matteucci. These propositions concisely were,—

1. "That muscular contractions are excited by the development of a fluid in the animal machine, which is conducted from the nerves to the muscles, without the concurrence, intervention, or action of metals."

In proof of this proposition, Aldini procured the head of a very recently killed ox, which was placed upon a table; also the posterior legs of a recently killed frog, which he held in one hand by the feet, so that the large *ischiatic* nerves hung down, and thus he caused the tip of the nerve of the frog to touch the tip of the tongue of the ox, which had been previously drawn a little out of the head and mouth. The circuit was completed by taking hold of one ear of the head of the ox by his other hand, also thoroughly wet. The instant the contact was made, there was contraction of the frog's legs, and the contraction ceasing the instant the circuit was broken. He also showed, that the intensity of these contractions was much increased by arranging several heads in a series, much as M. Matteucci did with the pectoral muscles of *pigeons*, some forty years afterwards.

He next so prepared a recently killed frog, that by holding up its leg by its toe in his fingers, and allowing its ischiatic nerve to be pendulous, he could bring its nerve in contact with its own tongue. Contractions instantly ensued from the current of electricity that thus evidently traversed the frog's leg, in its route from the external or periphery, to the internal or mucous covering of the body. If we interpret this experiment aright, it certainly demonstrates the existence of the musculo-cutaneous currents, and completely anticipates its discovery by Donne, some thirty-five years after. He substantiated those results by referring to the then physicians and professors of Guy's and

St. Thomas's Hospitals, who were present to witness the proceedings. His next statement was, —

2. "That the proper electric current of the frog is competent of itself to produce muscular contractions."

For the purpose of showing this, he prepared the posterior extremities of the recently killed frog that had been vigorous, and by bending up the leg, he brought the muscles of the thigh in contact with the lumbar nerves, when contractions instantly resulted.

Next Aldini took the prepared and separated frog thighs with their long ischiac nerves intact, and placed a ligature loosely around the middle of one of the nerves, which was then applied to a corresponding muscle; contractions ensued; but on tightening the ligature convulsions ceased. This statement, as remarked by Golding Bird, is highly important, for upon its accuracy or error hinges and depends what has been regarded as one of the tests of the *identity* or *diversity* of the electric and nervo-electric agencies. As soon as this phenomenon was announced, Dr. Valli repeated and entirely corroborated the result, with some modification; for he says, "I found that when the moist, tight ligature was applied lower down and near the muscle, it prevented the contraction; but if it is placed farther up, that is, near the spine, it will not prevent it." These same results were soon after corroborated by Von Humboldt, and still later by Professor Matteucci, who says, "If care is taken to insulate the nerve, a tight ligature does arrest the contractions." Before leaving the subject of Galvani's discovery, it is but justice to state that since Professor Matteucci, Golding Bird, and other writers have given currency to the statement that the curious phenomenon observed by Galvani was not original with him, (but that it had been made some time before by the celebrated Swammerdam, and that the experiment was exhibited by the latter in the presence of the Grand Duke of Tuscany,) this is *not found to be so*. The experiment referred to, says Dr. Althaus, of London, was for demonstrating nervous irritability from mere *nerve irritation by mechanical means*. Galvani's discovery was original. As to the contention between the two

illustrious philosophers, Galvani and Volta, there can be no shadow of doubt that the latter was wrong in denying absolutely the existence of animal electricity, because electricity was developed by contact of moist metals; so was Galvani wrong in seeing the muscle contractions only in the light of an effect of animal electricity, whatever might be the condition of the experiment. Volta was doubtless right, as to the explanation of the facts in the first experiments of Galvani. So was Galvani right as to the fact, and law, that muscle contractions are produced by the native animal electricity itself. For, by actual trial Galvani also showed that in warm-blooded animals there exist natural currents of animal electricity, directed from the extreme portions of the limbs towards the larger nerve trunks, and so on to the body. But this also was doubted for very many years, until, by the beautiful and strict researches of Dubois-Reymond, it has been completely confirmed. So was the third experiment of Galvani objected to by Volta, and rejected by the most of learned men also, because opposed by the latter on the grounds that the electric current then produced was from "*contact*" of dissimilar substances, as muscle and nerve; but, as we have shown, Galvani even succeeded at last in bringing about contractions by simply connecting the ends of the two large nerves of the frog thighs. This last result was flatly denied by Volta, but as strongly maintained by Baron Humboldt.

Years passed on. A very sensitive galvanometer multiplier having now been constructed by a German philosopher, the heat and bias of old prejudices having died out with the departed generation, and there being now no Volta, M. Nobili, of Riggio, took up the matter for thorough work, and from first principles, where Galvani and Humboldt had left them thirty years before. He was enabled to show again, and now conclusively, in consequence of new facilities, that there does actually exist in the leg of the frog, naturally, an electric current, or, in other words, *a nervo-electric current peculiar to the living animal.* The magnetic needle of the sensitive instrument he employed was deflected to 30°, by *the current proper of the frog.* This current he found moved in the direction from the muscles to

the nerves, and from the feet to the head. This action was often seen to continue for several hours, as the tissues of cold-blooded animals maintain the properties of life much longer than those of warm-blooded animals. Thus M. Nobili, in 1827, ascertained and demonstrated these facts, by means free from every objection, and denominated the phenomena "*the current proper of the frog*." Nobili found, if he touched the nerve and muscle of one frog, with the nerve and muscle of another frog, that there was no effect on the delicate galvanometer needle, showing that the one current was opposed to the other, and thus they balanced; but when he placed the nerve of one frog in contact with the muscle of another frog, then the needle deviated and a powerful contraction took place. But we must not follow now the fascinating progress of M. Nobili; for we are already arrived at the very portico of electro-physiology, that leads into a new and spacious wing of the temple of science. Here we shall find not only the cabinet of nature's laws by Nobili, but on the one hand we find Matteucci, and Marianini, and Volta, and Faraday; while on the other are Baron Humboldt, Dubois-Reymond, Todd, Copeland, Becquerel, Remak, Duchenne, Brown-Sequard, — together a mighty host. Let us then retrace our steps, and observe first what contemporaries have been doing since Humboldt left those countries for his memorable travels through our own America.

### *History of Electro-Physiologic and Electro-Therapeutic Researches.*

I consider those observations, so early made by MM. Volta and Ritter, as being suggestive and important. Dr. Volta says, "These experiments can some day become applicable to physiology, as well as aid to the practice of medicine." But these expectations and prophetic declarations of that great physician are not as yet fulfilled, nor will they ever be realized fully until "the experiments" are directed *more to feel the way* to practice, rather than to discover the so-called *theory of convulsion*. Let but these same men turn their efforts to tracing the work-

ings of the different currents on the living organism in a therapeutical point of view, and substantial truths will soon accumulate; but we must first patiently investigate what has already been done.

M. Marianini, in 1829, and Nobili, in 1834, were the first to take up Volta's researches for thorough investigation. Marianini at once declares himself at some difference from Volta's views, because he supposed he found a difference in the opening convulsion; i. e., the twitching that occurs on opening the circuit; and this according to whether the current flows through the muscle, or whether it flows through the nerve trunk. The former he termed *idiopathic*, the latter *symptomatic* convulsions. In the first case, he thinks that each current direction, and in the latter merely that one running opposite to the nervous ramification, will admit of an opening convulsion. When the current courses through the nerves in a direction contrary to that of their ramifications, it will produce, instead of a contraction, a *sensation;* but when in the same direction as the nervous ramification, i. e., down-running, it will cause the contraction.

Such researches and results are all the more important and interesting, because they were for the first time obtained, not from the amputated frog legs, but from trials made on the live frog, with the loins necessarily separated transversely, so that the legs were connected with the body *only* by the large nerves. Thus, when a current was directed upward through the nerve, it produced at the opening of the chain a convulsion. If the direction of the current was changed so as to run down, it occasioned at the opening of the chain merely a cry from the frog; but this did not invariably appear. As in those times, the theory of C. Bell, or the microscopic structure of the nerves, were not as yet known, it is no wonder M. Marianini did not more fully see the prodigious bearing of these results of his own researches, but which our present knowledge proves them to deserve; namely, that the down-running current affects the sensitive nerves more than it does the motory nerves; and that also the opening of the down-running circuit is felt merely in

the sensitive nerves; while the opening of the up-running current is felt merely in the motory, where the electric stream traverses a mixed nerve. But we find that Dubois-Reymond, more recently, does not sanction the terms *idiopathic* and *symptomatic*, but says, "We do not yet possess any grounds on which to establish the immediate excitement of the muscles to motion, by means of the current, as we have no right to ascribe two causes for one and the same effect, when one is quite sufficient to account for it."

M. Nobili thereupon produced the results of his researches, which can be considered as forming an *epoch* — a second starting point — in the history of this department of physiology and therapeutics. The greater part of his work, however, was also directed to *the law of convulsions*, which was always thought by those earlier writers as so important. But in the latter part of his treatise we find the following conclusions, or rather doubtful deductions; for he says, —

"By the rapidly repeated closure and opening of the circuit that embraces a frog thigh, there appears a phenomenon which bears the greatest resemblance to ordinary tetanus." Nobili seems to suspect that in this idiopathic and traumatic disease, the nerve fibrils are subjected to similarly rapid changes of excitement and relaxation, that, taken together, produces the tetanic spasms. He states that he has observed more than once, that a frog which, from some unknown cause, had fallen into a tetanus, has remained in that condition also during the working of one direction of the current; but, by reversing the direction of that current, the muscles relaxed. He alludes to this fact for starting the query, whether the steady current working in one certain direction, or perhaps in both directions in *rapid* successions, may not possibly constitute the very specific means for quieting the tetanus, or rather the means for preventing its development; but he does not seem to take into the account any sort of reference to the cause of the tetanus; it must be assumed that the cause of the tetanus is already removed. Let us now, says Nobili, proceed from tetanus to paralysis, and ask, what is the real condition obtained when we apply an electric

current to a paralyzed member? The steady and long *uninterrupted* working of the current produces a stupefying effect on the nerves so treated, i. e., to a certain degree, so as to rob the nerve of a part of its excitability. But the working of a *rapidly interrupted* current, on the contrary, has a tendency to produce the opposite result; that is, to retain the excitability of the nerve in such activity as to produce even an artificial tetanus. In paralysis we conclude the nervous system has lost its excitability. In tetanus it has acquired a too great excitability. The treatment for the cure must therefore be diametrically opposite; for tetanus, the continuous voltaic current, by a steady and protracted working, stupefies the nerve; while for paralysis the interrupted current is needed to excite the susceptibility from moment to moment.

Four years later, and M. Marianini declares that he finds that the *alternations* of Volta in the main are true; namely, that the longer working of the steady current direction makes the muscles insensible to the closing or opening of the circuit, if continued in the same direction; but that this sensibility is quite reëstablished as soon as the opposite current direction has worked about the same length of time, provided these currents are moderate, as from a single pair. On the whole, he finds that the excitability decreases according to the frequency and the duration of the current directions. He then tested these seldom alternations with different strength of currents, as from two to sixty pairs of plates in the pile. By taking a vigorous frog and subjecting the posterior legs to the action of sixty pairs for three hours together, he found that the together-drawings and twitchings of the muscles had lost scarcely any of their strength. It was only after another half hour that they began to grow some weaker; but this was increased again on changing the current direction. After another three hours, there was no perceivable decrease in the muscle contractions from the first, although the current had now been running in all, and continuously, for six hours, and that with but one change in the current. In short, it was found that only by a very long duration of the current, there was noticed any further reduction in

the contractions, and that by the change of the current direction these were restored again.

According to these results, says Marianini, there exists in *living*, healthy animals, *a repairing force*, which was here manifested by restoring the contractions produced by the protracted electric current. In fact, as soon as a live frog has become weakened from the teasings of electric experiments, if it is allowed a time to rest, it reacquires its original strength, and the contractions show the same force, (without the necessity of changing the current direction,) as was observed at first. According to him, this *repairing force* continues in some degree in the recently amputated frog leg, but then only for a short time, for the longer the time that has elapsed since the section, the shorter in-working of the current is required to make visible the reduction of its excitability, which simply means, *lost strength*, as first discovered by Volta.

# CHAPTER III.

## ELECTRO-PHYSIOLOGY.

### *Electro-Biology.*

THE researches of modern physiologists have clearly shown that all *organic beings* are resolved into ultimate cells, and that the functions of growth and nutrition are performed through these cells. Here, then, is the nucleus and sum total of life. But the great French physician, Bichat, says, "Life is the sum of those functions by which death is resisted." Life, in its widest signification, says Dr. Alfred Smee, is a term to designate the combined functions of assimilation, growth, nutrition, excretion, &c.; that these changes, occurring in the organization of man, constitute the vital phenomena of life; that these, together with the action of the senses, of thought, memory, reason, word, and deed, are consequently subject and obedient to physical laws; and that the functions of animal life are alike obedient to the fundamental law in physics, namely, that no force can possibly be generated without some corresponding equivalent change in matter. This is demonstrated in man, as we observe after action; for there is an increase of excretion, with greater desire for food and rest.

With regard to these ultimate cells of animal bodies, one of the most wonderful and extraordinary results which I have observed is, the action of electricity by induction, as obtained in the interrupted to-and-fro currents of electro-magnetism. But to study them in their nicest forms we often must have recourse to cases where they are found to exist in the simplest conditions. When the web of a frog's foot, for instance, is placed in the field of the microscope and this kind of current is directed through

the living animal, the circulation in the vessels of the foot tissues is seen to stop instantly, as if by magic. The current of venous blood which naturally flows from the capillaries towards the larger veins, as seen just before, not only stops, but also soon begins to retrograde slightly; while the current of arterial blood (just before observed as flowing in the smallest ramification of arteries *towards* the capillaries) is seen now to tend a little towards the capillaries, and even to be drawn into them, while the capillaries are all enlarged. The consequence is, they are engorged, as we also can see them under the skin by the naked eye. When the electric current is withdrawn, after it has been running for about a minute, the blood is seen to move on again, flowing in its natural order, both in the veins and in the arteries, only more rapidly than before the trial, and the engorgement soon vanishes. But on applying the electric current again, the same phenomenon is reproduced. The action of the current is as marked upon the lymph corpuscule as on the common blood corpuscules; and this we hold to be a very significant fact, because they move flowing rather along the *side* of the vessels, and are therefore less acted upon by the *vis a tergo* of the heart's action.

But we may be asked, How do Galvanic or Faradaic currents act upon the living human organism? Or rather, What are the first radical effects? Dr. Alfred Smee thinks the surface pole of the *peripheral battery*, in his scheme of nervo-electric battery of animal life, is excited to increased action, inasmuch as when two needles are placed respectively the one in the skin and fascia, while the other is plunged deep into the substance of the live muscle by the closure of a conductor between them, there is indicated by the galvanometer a decided *native current*. But this does not answer the question. If it were put to me I would say, In part it is known, but in part we do not know. The every where present *vitality*, unknown and yet seen, in all parts of living bodies, is the *mainspring* of life; but as no one knows what that is, *who will attempt to explain it?*

M. Matteucci has proved that there exists in the muscles a material which is highly nitrogenous and *acid*, while in the blood

the nitrogenous materials are *alkaline*, and the nerves are *neutral*. The voltaic arrangement of the human body consists in animal membranes and fluids, with nerve-fibres for connecting; and the result is, the most exquisite self-sustaining battery arrangement, that yields a kind of constant voltaic electricity, modified by vitality. It was Philippo Pacini, an Italian physician, who, in 1830, first described nerve-corpuscules, or appendages to the cutaneous nerves, as found particularly at the wrist, elbow, thigh, and intercostal spaces, and also in the solar and sacral plexuses. These *Pacinian corpuscules* were, possibly, noticed as early as 1741 by Lehmann, which he termed *papillæ nervosæ*. In each of these corpuscules there is a terminal nerve filament, and also an arterial radical. They doubtless have to do with the electro-nervous battery, as a whole; but what their office is, is not fairly known.

It is known, moreover, that minute cells are found throughout the gray matter of the brain, which may be supposed to be the active portion, and possibly the central poles, of the electro-nerve power. Here the requisites of arterial blood and of nerves are supplied in the greatest abundance, so that the brain is literally nothing but nerve fibres, blood vessels, or nerve tubes. In fact, the whole of the white layers — as, for instance, the *corpora striata* — are mainly nerve fibrils; while the gray portion is mostly supplied with blood, and that in a truly wonderful structure. The mechanism is here complex; yet is it still more and more beautiful and wonderful every step we take in understanding it as a means to an end, designed and built by the all-wise Architect as the *nicest* of his material works.

There are strong reasons for believing, says Alfred Smee, in his "Electro-Biology," that the brain is a double organ, and that the two impressions — when received on each side of the body or limbs — give but one idea to the mind. To preserve this doubleness of the apparatus — that is to say, to have the action in duplicate — each nerve fibre must be connected with a corresponding nerve fibre on the *opposite* side of the body. Thus two distinct systems of brain apparatus are formed, of which one is exactly the duplicate of the other; so that any action on

the one side is manifested on both sides alike. The mode of arrangement appears to vary in certain parts; for instance, as in vision, as a very peculiar contrivance is seen in the commissure of the optic nerve. Here the two inner portions of each probably divide: the one part continues in its course, while the other crosses over to its neighbor. In this way the sum total of the field of vision is represented on each side of the brain. To a degree, therefore, it must be true that the actions of the body have a definite source in the gray matter of the brain, as anatomy and pathology show. From these facts we should expect that a severing of the *pedunculi cerebelli* on the one side would determine a motion *towards the opposite* — a fact which actually occurs; "for of all the singular physiological effects which can be produced, there is none more remarkable or instructive than the continued whirling, revolving, or rolling motions of an animal *thus* injured," says a distinguished naturalist of the present day. I refer to Dr. E. Brown-Sequard.

If, then, (as it seems plausible to suppose,) the peripheric nerves of all the body and limbs are one pole, while the brain is the other pole,—i. e. the former the positive and the other the negative pole of the electro-nerve circuit, — we can in some measure see why the actual transition from pleasure to pain can be so near and sudden. An impression can be made on any part of the body with more or less pleasure to a certain pitch; but beyond that point, pain immediately ensues, which, if sufficiently increased, can be followed with palsy: this, if increased still greater, can be followed with death.

If a very minute or delicately thin piece of metal be placed in a glass tube, and a large electric current be now passed through it by bringing it in the circuit of an active battery, the metal will then be likely to be instantly dissolved, and the circuit might not be readily completed by that route again. Dr. Smee says that what is true in this respect of such a pole is true also of liquid poles, and of intervening fluids. Where repair is constantly necessary, as it is in the brain, a very strong impression would more than equal the ordinary supply; and this action through that delicate combination and medium might thus be stopped.

The effect upon the brain in such a case appears to amount to more than exhaustion, as the delicate mass appears to be damaged permanently, and the action through that particular route does not readily, nor yet even always, again take place. It is on this ground, doubtless, that strong moral emotions sometimes instantly destroy life; for if each little sub-battery of ganglia, or of periphery, do affect the great central nerve battery, so that a very strong impression made on the brain could influence by *reflex action* every nerve of the body, then if this action is so great at any given time as to *quite* exhaust them, vitality is done, and life must *necessarily* be extinct.

It is not a little interesting, says Dr. Smee, in his *Sources of Physics*, to notice that *desire* in mental operations is similar in all respects to *tension* in the voltaic battery. When the desire is gratified, it ceases for a time. This phenomenon is precisely similar to an exhausted battery in which an arrangement exists for replenishing the exciting fluid, as, in this case, after a time the battery would again become active and exhibit tension; and this is the same as desire ungratified. Hence he concludes, that man is perfectly free to act in any manner from external impressions; but after he has once received those impressions, they also wonderfully influence his future course. When the moral law is *profoundly* impressed on the brain battery, this will predominate, control, and rule each specific instance; but if feebly impressed, then each immediate impression is not controlled, but is controlling, and then the individual acts according to the more immediate pleasure or pain.

From these considerations man is taught that his *mental* functions proceed from the integrity of his brain organization. If it is incomplete, then the mental phenomena must be imperfect. A skull that is manifestly incompetent in size and proportion to contain the *usual* entire central electro-nerve battery indicates that the individual is deficient in mental power, *unless the contained brain is fine and high-toned.* True, we sometimes see perfectly-formed skulls, and those of *ample* size, with atonic or atrophied brains inside; and the result is a very small mental capacity, or even idiocy. Hence the author cordially concurs in

the deductions not only of Hugh Miller, from pre-Adamite nature, but also with Dr. Alfred Smee, upon this subject, i. e. *we know from the very organization of our bodies, that we are immortal;* that God *exists;* that there is virtue and vice, and eternity with its conditional rewards.

Man, in every age, climate, and continent, is compelled by his very *construction* and *nature* to believe *these first principles.* That which is infinite must not be limited; time must not be confounded with eternity, matter with space, the body with the soul, nor yet material actions from physical causes with God and his special providence. Thus are we taught the importance of religion, and, *a fortiori*, the absolute necessity that this should be pure, holy, and undefiled. Let the teachers of religion, and the teachers in all departments of science, *rest assured*, says Professor Phelps, of Andover, that they will approximate *inevitably*, although by opposite roads and methods, to the exact, self-same truths, which are for the very best well-being of the body as well as that of the soul. The former may influence man *from general principles* to control each specific act, while the latter, through the inflexibility of nature's laws, trace up each specific impression and action to a whole under general laws, *and these all, if they be true, must both essentially and minutely agree.*

The human species can have cognizance not only of single sentient impressions, and of combined sentient impressions, but we also derive a single idea from the sum total of all the impressions of each sense. This capacity is believed to belong to man alone, and is consequently a proof of mental power. Now, this is found most beautifully illustrated in those practical galvanic arrangements for obtaining a *single impression* from a multitude of separate actions. It is only necessary there to connect all the combined voltaic arrangements, so as to act as a single battery, which will then exhibit *action*, whether one, a part, or all the separate batteries are excited. It is, moreover, imperatively necessary to assume a mechanism in man, which shall collect the ultimate combinations of the respective senses into one whole, and this is inferred from voltaic laws, and is believed to

be found complete in the structure of the brain; for it is now manifest that almost every structure and arrangement here found may be nearly imitated by voltaic arrangements, combinations, and manifestations.

When we take into consideration the general alterations occurring in the brain as well as in all the body, it by no means follows that exactly the same change in degree or kind occurs in both. This includes that vastly comprehensive subject of *waste and repair;* for, as says a philosopher, "we can no more obtain light without consuming oil, or its equivalent, or heat without the combustion of fuel, and that too with the product of soot and ashes, than we can obtain animal force without the creature receiving food and excreting the debris." Bright arterial blood must flow throughout the whole from pole to pole, i. e., from the centre to the surface corpuscules, and so to the stations of ganglia and to the brain. The electrolyte of both extremities of these nerve routes is liquid, and as healthy serum contains neutral salts, it is under all the better state for exactly such electrical purposes, *minus* vitality.

It *is* a *law* of the voltaic circuit that no polarity can occur unless there be some difference in the two poles, either in reference to their individual power of combining with oxygen, or from other circumstances that places them in different relations, such, at least, as variations in temperature, in extent of surface, in state of surface, or in their fluids having a different affinity for the given pole. Now, when we have a difference even in any *one* of these respects, then we as certainly have a voltaic circuit, determined *from* that pole which renders most capable for combining with oxygen.

In reference to the changes taking place between the elements of protien, which is largely contained in muscles, Liebig says, the elements of protien, starch, oxygen, and water undergo transformation together, and mutually affect each other. We obtain, as the product of this metamorphosis, urea, choleric acid, ammonia, and carbonic acid; and besides these, no other product whatever. We here have the chief constituents of animal secretions and excretions, viz., carbonic acid, as elimi-

nated by the lungs, urea and ammonia by the kidneys, and choleic acid secreted and eliminated by the liver into the duodenum, and from thence out of the body. Now, all these changes appertain to the peripheral nerve batteries, from whence comes our main source of physical power. Other transformations are also going on at the brain pole, particularly those in the gray substance, where phosphorus and red blood are *most profusely* provided; for certain it is that mental labor, or a nerve exhaustion from any cause, *always loads the urine richly with phosphates*. Now, this change of matter causes a continual waste, and demands a new supply; indeed, if not supplied or remedied, that individual will rapidly dilapidate. The changed matter, which has become the effete material, will *clog* the system, and interfere with the nervo-voltaic actions, or overtax the particular organs that continue to eliminate it. Organic disease will soon follow the functional derangement. This is sometimes a great perplexity to the physician; but what is difficult for us, Nature effects systematically and with the greatest perfection, particularly if we aid her.

We perceive that the blood absorbs the carbonic acid just as soon as formed within the capillaries, from the galvanic results, and now it is called *venous blood*, as it sets out with this its normal freight, washing it along to the lungs to be exhaled. Urea is also absorbed by the venous blood, and carried rather to the kidneys, while the choleic is cast off through the corpuscules of the liver. If the first important process be stopped but for five minutes, death is the result. If the second is stopped for five days, life may be extinguished. If the third be actually stopped still longer, shorter in some than in others, and that in proportion to the vicarious actions, life dies down inevitably to extinction. This proves that the animal battery for animal electricity must be kept clean; the batteries must be *recharged*, on and on, by taking suitable food and medicine, and we must as regularly and faithfully eliminate the resulting debris.

The actual bearing of these investigations, I need hardly state, in the way of both *general and special principles* in this

department of medicine, is in the highest degree instructive. It shows that in whatever process or function of the human body the blood is most essential, these, nothing less than true voltaic or animal electric actions and *life force*, must also have an influence. Furthermore, since it is self-evident that the circulation of the blood has thus to do, more or less, with every operation of the living body, I will only add that these experiments and considerations demonstrate the vast importance of employing artificial electricity, if possible, *as a co-worker with nature's similar actions in our organisms* as a rational, natural, and extensive remedial agent.

*Vital Force.*—M. Paget distinguishes vital force from all others *by its power of generating typical organic forms.* It is well known that the saturated solution of the neutral salts, when added to the human blood, contracts the vesicular substance closely around the nucleus; also, that the fixed vegetable and volatile alkalies corrugate the vesicles. From this it has been concluded by some physiologists that nature has set certain limits to the proportion between water and salts in the blood, and that the latter are destined to preserve the peculiar disk-like form of the blood corpuscules. But we are inclined to the more general belief that this is rather a vital phenomenon, from its constant occurrence and typical variations in the different classes of the animal kingdom, and as not the results of electrical, chemical, or physical forces.

The starting points in every physiological and pathological process by which a part grows, or multiplies, are in the nucleus of the blood-corpuscules, or in the germinal membrane. It is now believed that there is no such thing as spontaneous cell-development. That is, every cell, whether it be a blood-corpuscule, a muscle, or cartilage, or bone-corpuscule, has its origin from the nucleus of some previously existing cell. This seems to be a general law, which pervades all living organisms, animal and vegetable, and in accordance with which they attain the sum of their vital entities, and then endure for a while, or perish in giving birth to other like structures.

The blood, then, is not a permanent tissue, regulating and

propagating itself out of itself, but is constantly dependent upon other parts. Its elaboration is the work of the cellular elements of the body; and its corpuscules, according to Virchow, Kölliker, and Remak, are but so many *floating* glands. Hence every dyscrasia depends upon a more or less permanent supply of noxious materials. While normal blood originates in the blood-making, glandular system, as the lungs, liver, spleen, thymus and thyroid, supra-renal pituitary, pineal, and lymphatic glands. When either of these glands is damaged or diseased, the blood deviates.

The question, What causes a numerical hypertrophy of these glandular organs? and thus changing the constituents of the blood, is as yet unexplained. It probably depends upon the vaso-motor nerves, or something which affects the nutrition of their individual cellular elements; but whether this change is primarily due to vital or physical influences is as yet wholly unknown to us.

In speaking of growth and secretion, Bennet fully admits, that, while the blood is transformed into tissues and secretions, it cannot be attributed to any power residing in the blood or blood-vessels; but that the attractive and elective powers of the economy are seated in the tissues themselves; while it is equally true that "*the life of the flesh is in the blood*," and that "an eternal law of continuous development prevails."

There are now entertained two distinct theories in regard to the mode of origin of the blood-corpuscules. The first — that of Dr. Wharton Jones, Bennet, Virchow, and of the cellular pathologists generally — is, that they are of an epithetial origin, and are only the transformed nuclei of the cells of the lymphatic glands. The second theory is, that the blood-corpuscules originate in the circulating fluids by mere molecular aggregation; that chylification and sanguinification are perfected through the action of the lymphatic glands upon the passing molecular chyle; that in them the blood-corpuscules are formed, and conveyed by the thoracic duct into the circulation at a point not far from the right side of the heart; from thence they are rapidly propelled into the lungs, where, in being exposed to the oxygen of the atmosphere, they

assume color, and thereby become the colored corpuscules of the blood. Thus the whole adenoid substance of the intestine, that of the follicles as well as that of the parenchyma of the villosities, and of the interglandular tissue, may concur in the formation of the blood-corpuscules: that is to say, that the cells accumulated in this substance are not destined to remain there, but to pass at first into the chyliferous ways, and thence into the torrent of the circulation.

Thus the blood-cells are formed either with or without nuclei, according to the particular stage of their age or growth, — the younger ones containing them, the older, not, — the power of self-multiplication residing in the cells themselves, and not in the molecular fluids by which they are surrounded, and which only serve as material for these changes. Thus the blood holds in solution the living and the dead materials of the system, to be disposed of in different ways, while the blood as a whole is modified still further by the nerves and other tissues that surround it.

The processes for life in the blood, and force in the muscles, cannot fully take place without good nerves and their due action. That is, in proportion to the health and integrity of the nerves in a given limb, the capillaries are more or less complete, the venous blood has its full characteristics, the muscles are nourished, there is health, there is strength, and the recrementitious matters are thrown off.

It is familiar to every one that it is important to have good, pure, arterial, red blood in the system; but we here insist that it is also important that this arterial, red blood should be thoroughly changed to venous in passing through the tissues. The diminished depth of color in the veins observed in paralyzed limbs is due, at least in part, to the state of prolonged inaction of the muscles. So, also, may a paralysis of the blood-vessels themselves allow a reddish color in the venous blood. The blood in the veins of limbs paralyzed by section of their nerve-trunks, or by destruction of a part of the spinal chord, is of a less deep, dark color than is usually found in veins of sound limbs. But it is especially through nervous influence, in exciting muscular

contractions, that the animal galvanism and molecular chemistry increase the intensity of the dark color in venous blood.

The blood is made arterial-red by the lungs, provided a plenty of pure air reaches it, and thus these influence it; so is the blood made venous, dark purple by the influence of the nerves, provided they influence it: and these two processes — the one making, and the other appropriating, the life-giving qualities of the blood — are equally important for life and health, for muscular force and physical endurance.

*Organic Molecular Motions.* — These motions of the minute organic and inorganic elements are incessant during the ceaseless rounds of organizing and disorganizing actions, of which every tissue is the seat, from the moment of conception and life, as long as that human organism continues to live. These molecular movements are visible, by aid of a microscope, in nearly all the internal processes; the producing force being developed by the processes connected with life, it ceases with life. Of the minute movements occurring in the interior of the body we may classify three kinds: —

*a*. Those where particles are moved passively by forces independent of themselves.

*b*. Those connected with the incessant changes of the organic elements of the tissues.

*c*. Those which occur in certain entire tissues on the application of an appropriate stimulus.

All these movements, according to Todd and Bowman, may be considered molecular, on account of the minuteness of the particles concerned in them. Thus the introduction of new matter as nourishment and force, the removal of effete particles by processes of absorption, the transfer of nutrient matter from the blood to supply the place of the particles thus removed from the tissues, the separation of organic compounds in glands, besides many other actions in all, cannot take place without thoroughly diffused, and yet definite, movements of the molecules in the textures concerned in these processes. Radcliffe considers that we are as much at liberty to infer that these motions are produced by certain affinities of the particles of said tissues, as that the

chemical action is the result of affinities between certain forms of matter. However, these motions are generally, if not always, due more or less to some kind of extraneous force or forces acting upon the particles moved.

*Ciliary Motion.* — This singular phenomenon, distinct from peristaltic motion, is microscopically seen in the living human body, and should probably be placed in the same category with the molecular motions. It is now well known that there are certain internal surfaces, which, in their natural and healthy state, are lubricated by fluid, and are covered with a multitude of hair-like growth, or processes, of extreme delicacy of structure and minuteness of size, called *cilia*, from *cilium*, an eyelash. They are attached to the epithelium, are tapering to a point, are situated in rows, so as to thickly cover the surface, and each one is about a thousandth part of an inch in length. During life, and for a certain period after death, according to Todd and Bowman, "these filaments exhibit a remarkable movement, of a fanning or a lashing kind, so that each cilium bends rapidly in one general direction, and returns again to the quiescent state. The motion, when viewed under a high magnifying power, is singularly beautiful, presenting an appearance somewhat resembling that of a field of grain when agitated by a steady breeze. Any minute objects coming in contact with the free extremities of the cilia are hurried rapidly along in the prevailing movement: for instance, one or more blood-disks, accidentally present, will sometimes pass rapidly across the field propelled in this way; and very minute particles of powdered charcoal may be used to exhibit this phenomenon, and to indicate the direction of the movements."

We learn two important points in connection with these peculiar, and, I may say, almost exceptional, facts; and the first is, the truly molecular character of these movements under their peculiar fluid; and, secondly, the apparent independence of these motions of both the vascular and nervous systems. A wide range of experiments and observations seems to establish this conclusion; also, that electricity restores and increases this action.

These ciliary organs and motions, in man, are ascertained to

be peculiar to the surface of the ventricles of the brain; on the choroid plexuses; on the mucous membrane of the nasal cavities; on the roof of the pharynx; near the Eustachian tube, extending into and throughout the tube itself to the cavity of the tympanum; in the lachrymal canal; on the lining membrane of the female organs of generation, from the os uteri to the fimbriated margins, &c. Their motions may possibly be the result of ganglionic inervation, or of the attraction of endosmose, or from the chemical change which occurs in the fluids in contact with them; for a movement of their internal granules may sometimes be observed.

*Functions.* — Those of the human organism, as a whole, are generally spoken of as *animal* or *organic*. Under the former we include those functions which are peculiar to, and characteristic of, the animal part of creation, viz., *locomotion* and *innervation*. The organic functions are *digestion*, *absorption*, *circulation*, *respiration*, *secretion* (including *excretion*), and *generation*. In all these the nervous system exerts a certain control, and influences, to a certain degree, the performance of a given function, although certain of them are considered by some essentially independent.

### *Physiology and Electro-Physiology of Nerves.*

*Nerve-structure.* — Sufficient is known now to determine pretty accurately the ultimate structure of nerve-elements, and to show their general relations in the great nerve-centres, as well as in their course, and at their periphery. There are certain general laws of nerve-structure upon which all are agreed, but upon matters of detail wide differences still exist. By far the most important new fact is, that *the glangionic cell is the centre, origin, or terminus of every nerve-fibre found in the human organism.*

*The Structure of the Nervous Tissue* is most clearly and beautifully seen through the compound microscope when cut while frozen in their transverse sections, by means of a double-edged knife, as performed by Dr. Rondanovsky. The primitive ele-

ments of the nerves are seen to be pentagonal or hexagonal tubes. Their connective tissue walls appear as a network, leaving, in some places, between the tubes themselves and between the bundles of tubes, star-shaped closed cavities, *reservoirs*, by which the nutrition of the nerve is effected.

The cylinder axes are seen in the centre of the tubes as knotty fibres, surrounded in the nerve-tubes by the white substance; and the cylinder axes give off transverse fibres, which pass through the walls and communicate with similar fibres of other cylinders. These transverse fibres are given off at about equal distances, and are found in both anterior and posterior roots of spinal nerves. As a whole, in the composition of a bundle of tubes, there enter large, fine, and finest tubes. Of the fine and finest tubes the number varies in the different nerves, and even in the different bundles. They have the same complete structure as the larger tubes with their cylinder axes, and are found plentiful in the posterior roots of the spinal nerves. The fine and finest tubes very probably belong to the brain, where they are seen to be the predominating, if not the exclusive, element of the white substance; so that every nerve contains, at once, an anatomical substratum of the brain, of the spinal cord, and probably of the ganglia. There are nerves which leave or run out of the central parts of the brain and spinal cord as tubes, and others that are not so.

The nerve-cells should, without doubt, be considered as the origin of the nerves. They differ in size and shape, in having or not having prolongations, and in the number of these. The gray substance of the central organs is composed of cells and nerve-fibres, like their prolongations, or branches; the white substance is composed of tubes with the characteristics of those in the nerve-trunks and branches. The nerve-cells unite, in some parts of the central organs, by some of their prolongations, thus forming a mesh-work, in the angles of which are the nerve-cells themselves, forming a network of nerve-cells. In other parts of the central organs the tissue of the gray substance shows meshes formed exclusively of nerve-fibres, thus making a network of fibres. These bundles of fibres bend in opposite directions,

especially on the surface of the optic thalami, thus forming a special arrangement of the meshes as a network of the knots. The meshes or network of gray substance are an essential form of the central parts, as much as the differing direction of the bundles of the fibres of the gray substance, or of the bundles of the nerve-tubes of the white substance. Thus some of the nerve-fibres of the gray substance curve or bend into the white substance, in which they appear as cylinder axes in the tubes of this substance. And some of the branches of the nerve-cells, which we see communicating by some of their arms in the group in which they are found, pass transversely to the axis of the spinal cord, and bend inwards, and so become parallel to this axis, and finally go to form cylinder axes in the tubes of the white substance.

Moreover, from recent writers, as Drs. Otto Funke, E. Pfluger, R. Remak, Helne, Meissner, and others, we learn that nerve-tissue, in its two distinctive varieties, gray and white, presents peculiarities — structural, chemical, physical, and physiological. The latter may be considered a complex attribute. During the past ten years the rigid mode of inquiry and reasoning, in the investigation of organic structure, has resulted in the formation of pretty definite laws; as the law of nerve-structure, and, —

1. Law of Nerve-excitation.
2. Law of Nerve-irritation.
3. Law of Nerve-conduction.

All nerves are composed of fibres and cells, which are called *nerve-elements*. The nerve-fibre consists of an external membrane of the white nerve-marrow, and of the central axis cylinder. This latter is composed of a material similar to, and continuous with, the contents of the nerve-cell. This we have seen beautifully displayed in the spinal ganglia. Dr. Stilling and others have supposed that the nerve-fibre and cell composed a system of fine, anastomosing tubules; but it is now shown by Lockhart Clark and Funke that Stilling was deceived by the artificial mode of making his preparations.

*The Remakian Fibre*, first discovered by Robert Remak, has been a subject of much interesting discussion. He considers

these fibres to be nervous, as do also Helne and Hyrtle. Valentin and Kölliker hold that they belong rather to the class of connective tissue.

*The Nerve-cell*, when regarded functionally, is the most interesting anatomical element in the human body. Numerous observations on the central organs of the nervous system prove that all nerve-fibres either originate or terminate centrally in nerve-cells. An a-polar nerve-cell, or a cell without processes, is now known to have no existence in nerve-tissue; and Wagner and others are inclined to doubt the existence of unipolar nerve-cells; so that we may conclude that nerve-cells are mostly, if not entirely, bi-polar or multi-polar. These cells vary in form and size; but in structure they are simple, possessing a cell wall, with contents more or less granular, often containing pigment granules, a nucleus, and a nucleolus. Just as in gland-cells, so in those of nerves, no morphological peculiarity exists by which we can determine their functional peculiarity. Nor can we determine whether a cell is nervous, or whether it belongs to the connective tissue-elements. But physiologically important is the fact that a nerve-cell not only receives and originates nerve-fibres, but also sends off processes which serve to connect it with other nerve-cells.

The idea which Valentin originated, some time ago, that, at the periphery, nerves formed plexuses and loops, and returned again in the nerve-trunks, is now almost entirely disproved. The fibres often do form plexuses, but these are not terminal, since out of them may be traced fine, marrowless fibres, which do not form loops, but have free endings. According to Kölliker, at the upper part of the central cavity of a Pacinian corpuscule, the pale, marrowless fibre, almost like an axis cylinder, is seen to split into two or three branches, which end in free, lightly granulated knobs. The muscle nerve-fibres in the lower animals also terminate in free ends. It is now assumed that this is so in man. A similar mode of nerve-termination is found in all the organs of special sense. But in these, which is very remarkable, the nerve-terminals undergo those peculiar modifications which are necessary to receive the peculiar impression

or sense that is to be conveyed to the nerve-centre. Moreover, a beautiful demonstration of the free mode of termination of nerve-fibrils is found in the electrical organs of the electric fishes Silurus, Torpedo, and Gymnotus. The living voltaic piles which are found in these fishes, and are capable of such marvellous power, are really nothing else than peculiar terminal appendages of nerve-fibres, into which the latter can be traced, either directly, as in the silurus, or after formation of a fine network of anastomosing, as in the gymnotus and torpedo.

*The Skin Nerves* in the human subject, those which convey tactile impressions, enter the papillæ, to end in the peculiar bodies termed *touch-corpuscules* by forming knobs.

*For Taste*, the nerves of the tongue terminate in the very points of the papillæ by forming club-like, blunted, or pointed *free ends*, like some kinds of moss or cut velvet.

*The Olfactory Nerves* are believed by Eckhard, Shultz, and Kölliker to terminate like those in the tongue.

*For Seeing*, in the retina the ultimate fibres of the optic nerve terminate, through the medium of nerve-cells, in those remarkable structures the "rods and cones," discovered by Corti.

*For Hearing*, the nerve terminals are much like those of the tongue. In the ampullæ and vestibule of the internal ear we may trace the fibres of the auditory nerve into the layer of epithelium which invests these parts. There are two forms of epithelial cells; one cylindrical, or conical, and yellowish, the other pale, spindle-shaped, and with a fine varicose filament on their internal extremity. It is now believed that the auditory nerve-terminals communicate with these thread-like cells.

*The Encephalo-spinal Nerves*, as a whole, are most conveniently arranged, and remembered, in the four following classes: —

1. The nerves of pure sensation.
2. The nerves of motion.
3. The compound nerves.
4. The sympathetic nerves.

The *first* class, according to Todd and Bowman, includes some nerves, namely, the nerves of touch and taste, which are mixed

up with those of the *third* class. But as the study of these senses cannot well be separated from the others, we are led to consider these particular fibres along with the other nerves of pure sense, namely, the olfactory, the optic, and the auditory. And as the peculiar function of these specified nerves depends upon their *peripheral* organization, as well as on their *central* connection, their physiological anatomy and electro-physiology necessarily involve that of the organs of sense. This class will, therefore, embrace the most simple, that is, touch and taste, as also those of smell, vision, and hearing.

The *second* class of cerebro-spinal nerves, as a whole, embraces the *third*, *fourth*, *sixth*, the portio dura of the *seventh*, and the *ninth* pairs of nerves, according to Willis; all of which are motor in function.

The *third* class embraces the *fifth* and the *eighth* pairs of nerves, and the spinal nerves.

The *fourth* class embraces only the Great Sympathetic or true ganglionic nerves.

### "*Hallerian Irritability*" *and Electro-physiological Experiments.*

The three different parties of physiologists who have sought for the true theory of *the proximate cause of muscular motion* are these: First, those who searched, through the aid of the microscope, for the "*ultimate fibres*," and hoped to discover, in their position, or structure, something which might explain their mode of action. Second, those who investigated, through *chemistry*, for affinities, combinations, combustion, electricity, and polarity. Third, those who contented themselves with the easier method, by laying it down as an indispensable article of physiological belief, that "a muscle acts by its own *inherent power;*" that is, Hallerian irritability ignores the doctrine of the absolute necessity of the intervention of nerves to bring about muscular motions; that muscles do ordinarily act through the agency of nerves, by orders of the will; but, on the contrary, it teaches that they may and do also act without the agency of will or nerves. These three propositions, from the days of Haller to

the present hour, are hotly contested questions among learned men. Nor will I refuse to commit myself upon this subject.

I do not believe that either one of these propositions is absolutely or exclusively true. But I do believe, that, if the three theories are taken as one harmonious, grand proposition, it completely answers the whole question. When we view the human body as verified in most of its fluids, as well as solids, and recollect that it is made up of known molecular structures, that have definite organizations in themselves, and a given relation to their neighboring molecules; that these are replenished with, and relieved of, the materials for repair and waste, and as the result of this, there is evolved heat, polarity of the molecule, and an animal electricity which is not subject to the laws of electricity as found in inanimate nature, but is governed by the still more subtile influence of *vitality*, — we may see what is life, and the source of motion.

That plants possess irritability, that is, that "they possess the faculty of moving" on the application of stimuli, will readily be granted; but it may certainly be questioned whether this faculty implies any inherent power of their own, as "the principle of irritability." But this supposed analogy between the physiology of animals and vegetables has been the foundation of much mischievous reasoning, on the nature of both, by certain philosophers, and has tended to debase the one and exalt the other; that is, to reduce the animal to a mere piece of mechanism, and to endow the plant with sensation and volition.

It is true that the motions of certain plants are calculated to impose a belief of their possessing some local self-moving power. There are, indeed, strong reasons for believing that the motions of several plants, as well as the opening and shutting of flowers, and those mysterious attitudes of leaves and tendrils that present us, in groups of plants, those varied *vegetable tableaux*, indicating certain hours of the day, time of season, or condition of weather, or even approaching weather, as well as many other vegetable motions equally wonderful, though less imposing, are produced not by a *vis insita*, but by those conditions that disturb their electric equilibrium.

The *Mimosa* withdraws itself from the touch, as if resentful of the injury offered it, and merits, in the figurative sense, the honorary appellation of *sensitive*. The still more wonderful *Hedysarum gyrans* supports its spontaneous motions without any visible external cause. But, notwithstanding these imposing appearances, certain external circumstances are actually necessary to the production of their phenomena. It is well known that their shades of color, motions, and attitudes are rendered more vivid by the presence of light, heat, and moisture; while they become faint where these agents act weakly, and cease altogether in their absence. If an acid be dropped gently on one of the leaves of the *Mimosa*, it shows no motions till the acid has had time to act, and then the motions are produced. Electricity is probably evolved from the decomposition of the vegetable fibre and juices by the acid. In fact, the application of electricity has been found to produce the usual motions of this plant. Long ago M. Dutrouil, member of the Society of Science, &c., at Bourdeaux, who had made "the irritability of plants" the subject of a memoir, bore testimony from actual experiment that the motions of the *sensitive plant* are caused by electric currents, because when brought in contact with a conducting body the motions occur, but when approached by a non-conducting body there was produced no motion whatever.

There is nothing unphilosophical in supposing the fibres of certain vegetables to be so peculiarly arranged, as has been conjectured respecting the molecular structure in animal fibre, as that the passage of the electric current through them, and thus changing their polarity, may cause their motion. The *Mimosa*, like the voluntary muscle of the amphibious animals, requires the contact of something to produce a change in the existing electrical condition of this plant; while the leaves of the *Hedysarum gyrans* are so constituted as to be sensible to the most minute variations in its electric condition, and present to our view a wonderful assemblage of natural electrometers, indicating a perpetual circulation of electric currents, but in varied degrees of quantity or intensity, elicited by the action of light, heat, and moisture, and preserving an exact ratio to their respective forces indicated by actual motion.

Dr. Francis Glisson appears to have been the first to use the word "*irritability*" in a physiological sense.* But he ascribed an irritability proper to all the tissues of the human organism, even to the fluids and bones; and thus "*motiva fibrarum facultas, nisi irritabilis foret, vel perpetuo quiesceret vel perpetuo idem ageret. Actionum igitur earum varietates et differentiæ earundem irritabilitatem clare demonstrant.*" But the great Haller was the first to declare the *vis musculosa insita;* † i. e., a property inherent in the muscular fibre that is capable of being excited to contraction, independent of any immediate instrumentality of a nerve whatever. This raised the question, "Are the motor nerves absolutely necessary to bring about muscular contractions and motions?" We must be reminded that Haller was the first to make the nice distinction between the *functions of motion* and the functions of *sensation*, while Sir Charles Bell, in later years, was the first to make the anatomical demonstration of a difference in the *organs* for producing motion and sensation; i. e., to show that there are *sentient nerves* and *motor nerves*. According to Haller, *irritability* and *sensibility* are properties totally unlike and independent of each other. He claimed, in short, that the *nerves* do not possess the slightest degree of irritability, since they are never put in motion themselves, whatever be the stimulus that is applied to them. He termed *irritable* the muscular fibre, and whatever of the human organism that contracts; i. e., that shortens from being touched by any foreign body. On the contrary, he termed *sensitive* the nervous fibril, and whatever of the human organism that on being touched by a foreign body, transmits to the mind the impression of contact, whether pleasurable or painful; and that sensibility is a property which ceases with life. That irritability, on the contrary, is to be observed for a certain time after life has become extinct. That if motion be brought about through the instrumentality of the nerves, *it is only by their conducting the orders of the will*, viz., volition to the muscles.

* Tractatus de Ventriculo et Intestinis. Batavor, 1691, p. 168.
† Elementa Physiologiæ, vol. iv. lib. xi. Lusannæ, 1762.

This creed of Haller, upon which the medical world has ever since been divided, was first opposed by Dr. Muzer, a distinguished German physician.* He first proved that there are nerves in all muscular organs, and maintained that the nerves are the only excitors of muscular motion. After the galvanic discovery, this of all questions was taken up afresh by both parties. (These items are introduced here because they have a direct bearing upon the subject; besides, we must be reminded that this question of *Hallerian irritability* is the "shading and light" of almost all the works given by the very distinguished names we are to consult.) One party, at the head of which was Galvani, Volta, and Valli, contended that muscular contractions were rendered most strong from the immediate *contact* of the metallic stimulus to the cut and raw surface of the muscle, without touching the nerve. But others, as Baron Humboldt and Dr. Fowler, thought that such test could never give a fair solution of the question since it is almost impossible to eradicate all nerve fibrils from muscle fibres. They, therefore, were led to conclude that irritability is a property of nerve and muscle as a compound structure.

Fig. 4. A View of Elementary Fibres of Voluntary Muscles; i. e., of animal life, magnified three hundred diameters, showing a cleavage under *strain*, both lengthwise and transverse. This also shows that lameness from *strained muscles* may result from ruptured fibres.†

* Erste Grunde einer Physiologie. Leipzig, 1771.

† 1. The longitudinal cleavage, also showing the molecular structure.

2. The transverse cleavage.

3. Incomplete fracture of a muscle fibre, following the opposite surfaces of a disk, which stretches across the interval, and retains the two fragments in connection.

4. Shows another disk, nearly detached, as often seen.

5. A detached disk of molecules, still more highly magnified, showing the sarcous element of muscle fibres.

6. *Fibrillæ* separated by the effects of violence from each other at the torn end of the muscle fibre.

7, 8. The two appearances, commonly observed under the microscope, by the single *Fibrillæ*. At 7 they are more highly magnified and appear rectangular; but at 8 the borders are rounded, and the spaces are bead-like.

Dr. Marshall Hall announced the same opinion some fifty years afterwards.* Whether the property of irritability belongs to the pure and isolated muscular fibre, or to the muscle fibre *combined* with the nerves, he thought, could not be positively determined by distinct experiment; and that irritability belonged, in all probability, to the compound structure.

The *law* of Valli and Ritter, which is a confirmed fact in pathology, is in truth the greatest hinderance to determining this yet unsettled question. That law is, "The nerves *may* die in a direction from the centre towards the periphery;" i. e., the large nerve trunks sometimes are annihilated, as from a central lesion, before the branching twigs; and therefore, while the trunk of a nerve may have lost all excitability, still the fine ultimate nervous fibrils, that so minutely ramify the muscular tissue, may have as yet retained more or less of their susceptibility to an adequate stimulus. M. Claude Bernard,† of Paris, has recently also demonstrated that the motor nerves lose their excitability from the centre to the periphery *only in case* they have been previously separated from their nervous centre. When the sciatic nerve has been cut off from its connection with the spinal cord, severe galvanization of the trunk of that nerve will, after a given time, cause no more contractions in the muscles; but if we now transfer the galvanizing to the branches of the nerve in the muscles, and near the periphery, some contractions will still be brought about. But if, on the contrary, the nerve had not been cut or otherwise severed, but had remained still in its normal connection and physiological relation with the spinal cord, quite different phenomena are observed: the nerve now loses its properties in the inverse ratio; i. e., *from* the periphery towards the centre. If the crural nerve of a frog is laid bare, and no more contractions are excited by galvanizing the nerve in or near the muscles, still are contractions produced, if the galvanizing is done near the cord; and if the whole nervous trunk has lost its excitability, contractions can even then be brought about

* Cyclopædia of Anatomy and Physiology, vol. iii. p. 29, 1847.
† Leçons sur la Physiologie, Paris, 1858, vol. i. p. 193.

by galvanizing the anterior root of the nerve near the spine. It is in this way that the nerves lose their excitability, if animals die either from hemorrhage or from *woorara*. This can be illustrated by taking a frog, and first cutting the lumbar nerves on the right side, then let the animal be poisoned by woorara. Now we shall observe that the nerves lose their excitability in the direction from the centre outward to the periphery on the right side, where the nerve was cut; but on the other side of the frog the nerves die in the direction *from the periphery towards the centre* — i. e., where the connection of the nerves was intact. Therefore the terminal branches of the nerves are presumed to be the first which are destroyed by the poison of woorara; and as, in spite of this destruction of the properties of these terminal nerve fibrils, the muscles still show a ready response to the galvanic stimulus, the existence of the Hallerian irritability is claimed to be proved.

Mr. Bowman, of King's College Hospital, London, has arrived at what he claims to be equally unanswerable conclusions, but in quite a different way. He appeals to direct microscopical observations, made on *living fragments* of the elementary fibres of voluntary muscles, which he had entirely denuded and insulated from every vestige of other substance, whether nerve or vessel, so that he had nothing but the pure muscular fibre.* He observed that if, by design or accident, a particle of foreign matter was included in the field of the microscope, so as to be seen to touch the side of the fibre at a single point, the fibre there exhibited a contraction, that was limited to the point so touched, and not involving the whole muscular substance. Hence Mr. Bowman concludes that the muscles *do possess* an irritability proper, capable of being brought into action by a stimulus topically applied.

M. Claude Bernard undertook another series of experimental researches on the physiological action of the woorara poison, which also throws light directly upon this subject. He took two prepared frogs, and poisoned one of them by inserting under the

* Dr. Althaus on Medical Electricity, London, 1859, p. 129.

skin a small bit of the woorara. At the end of five or six minutes the frog ceased to show signs of life, and the poison was then withdrawn, and a galvanic current caused to traverse a portion of the lumbar *nerve* of each of the frogs alternately. The muscles of the frog which *had not* been poisoned were immediately seen to show a powerful contraction, but not the slightest twitching occurred in the other frog. But when the electrodes were applied *directly to the muscles*, both frogs suffered commotions, and it even appeared that the poisoned frog preserved the property of suffering contraction from the stimulus *for a longer time* than the one which had not been poisoned. This is claimed by some as very conclusive evidence of the actual existence of an irritability proper of muscles. But M. Eckhard objected to this conclusion, as it was not quite certain that the last ramification of the nerves were thus totally paralyzed.

A good idea of, indeed, the exact structure of, elementary muscle-fibres has recently been seen, and demonstrated by M. Amici through the means of a very superior compound microscope. He has found that the single muscular filament is composed of a series of disks, excessively thin, and exceedingly near to each other, connected together by an infinite number of very fine threads, reaching from disk to disk, i. e., from the surface or circumference of one disk to the other. Not only so, but there was rendered sensible to the eye the *modus operandi* of muscle contraction, *which is a material modification in the arrangement of the particles of each muscle-fibre, evidently by virtue of their electric polarity, while receiving and propagating nervous excitation.*

When contraction takes place in the muscle, then those fine threads which reach from disk to disk are seen to bend inwardly, something like an hour-glass, thus bringing about an approximation of the disks, and hence *a shortening of the muscle;* at the same time the filament appears corrugated, like the bellows of an accordion, or the sides of a Chinese lantern; and within the rims of the disks there is seen, also, a fine, soft matter analogous to that which is found in the *infusoria*, and which seems to be the material of which the muscle is primarily formed.

*The Chemical Condition of Exhausted Muscles* has often been investigated, and the recent results arrived at by R. Funke, who has made extensive researches and experiments to this end, lead us to the following reliable conclusions: The removal of the blood from muscles that have been recently exhausted by excessive exercise — and this removal can be done in several different ways — enables the muscles again to respond to stimuli.

From hence it appears that the spent (tired) muscle is not in a state of exhaustion, — using that term in a strict sense, — for it still possesses in itself the conditions for developing force. Its incapacity for exertion results not from a deficiency, but from a superfluity, of material. A supply of nutritive material is, therefore, not primarily requisite to give it energy; but all that is required is the removal or the neutralization of the products of disintegration and exhaustion. This can often be facilitated by shampooing and faradaization; also by internal remedies. Muscles freed from blood in animals perfectly tired and exhausted, but otherwise uninjured, entirely and immediately recover after electrical excitation; and also somewhat less after injections of carbonate of soda, though this salt itself is usually a depressent of muscular activity, as shown by actual experiment. But its success here, probably, is due to its combining with a neutralization of the lactic acid and other carbonaceous matters formed and left in the tissues as the immediate result of rapid and prolonged labor.

Another difficulty here presents itself, in the diminished ability of the heart and arteries to push the column of blood through the obstructed parts; while it is also probable, yea, certain, that the vitality of both the blood and capillaries is so far annihilated in these cases, besides the debris of oxidation, that the mutual affinities between the fluids and the solids are lost. Time, rest, and often external and internal remedies are required to bring about complete restoration. Carbonate of ammonia with brandy punch internally, and a smart faradaization over the surface of the body, quickly done and often repeated, should be more often resorted to by the medical profession for arresting the sudden, rapid, and dangerous prostration that is such an alarming fea-

ture in the crisis of sickness, as in typhoid pneumonia, and other sudden attacks of depressing diseases.

In all healthy animals, no matter to what class they belong, or on what food they subsist, there is found, from careful experiments, a peculiar substance, resembling vegetable starch, existing in all their tissues. This substance, which Claude Bernard calls "*glycogène*," or liver-sugar, is abundant in proportion to the vigor and youth of the animal, but which entirely disappears under prolonged pain, suffering, or disease. When death is produced suddenly, none of it disappears. These are the invariable results, as shown by repeated experiments.

In a rabbit killed after suffering pain for five or six hours, no trace of the sugar-forming principle was found, and the flesh had a decided difference in flavor from that of a rabbit quickly killed. Fish teased to death show this loss of liver-sugar in them to be surprisingly rapid. The larger animals endure longer; but this loss of a nutritious and delicious property in flesh applies to all exhausted or over-driven animals, for their muscles are found to be nearly or quite deficient in *glycogène*, and yield a decidedly larger percentage of water than muscles in normal condition; besides, the blood of such animals will not coagulate, or coagulates very slowly and imperfectly. So that prolonged fatigue or agony is quite as injurious to flesh meat for an article of food as if tainted, or as if it had suffered spontaneous death from exhaustive disease. This becomes to us a very instructive and significant fact.

*Rigor Mortis.* — The muscles contract and become rigid as they grow cold in death. That this mortal rigidity is not from the same cause or power by which muscular contraction is produced in the living muscle, we infer from the following reasons: It is not immediately after death that this rigidity takes place. The muscles remain for some time in their ordinary state of relaxation and suppleness. It is, in fact, as Manford contended, not till after the departure of animal heat — a more or less slow process, and perhaps a preparatory step in the process of animal decomposition — that this contraction takes place. But when a partial dissolution of structure appears to commence before

death, as in putrid fever, plague, cholera, and from certain poisons, it never does take place.

It can be prevented from taking place by slow venesection, or by excessive exertion and fatigue immediately before death. The ox is over-driven to slaughter, or goaded and bled to extreme exhaustion, *to soften the muscles*, in those countries where the heat of the atmosphere will not allow of the usual method practised here of hanging the meat until tender. The rapid circulation, the excessive chemical action in the tissues, the feverish heat and nervous exhaustion cause a partial decomposition of the muscular texture before the final stroke is given; and the flesh of an animal thus killed, instead of possessing the natural proportions and firmness which we are accustomed to see it preserve, falls flaccid upon the dish, and "*keeps but a little while*," because it runs rapidly into putrefaction. From all which, this rigidity of the muscles after death — this act of supposed irritability, or so-called "last vital contraction," which, in fact, is nothing more nor less than an inorganic collapse of their substance — is the plainest proof of the departure of life not only, but also of the last vestiges of vitality. No earthly power can ever awake it to motion again.

Hence we may conclude that the nervo-electric polarity of the *motor nerves* is more easily disturbed, at least by the electric current, than the molecular equilibrium of the fibres of the muscles. But my own opinion is, that electro-muscular contractions are most readily obtained; i. e., with the least pain, and by means of a less current, and that more uniformly, if we place one electrode over the nerve trunk, while the other electrode is made to glide along nicely and obliquely over the farther side of the muscle — a manœuvre which is readily learned, but not so easily described.

Muscular motion consists in a change in the arrangement and composition of the matter contained within the ultimate fibres, so that they become shorter, and consequently thicker and wider in diameter; and simply this is contraction, and this latter moves the limbs. Nerves are distributed to all the muscles; but this supply is in a very unequal degree. The termination of the larger

muscle nerves appears often to abut on many muscle fibres, and also to be in *loops*, running likewise *transversely* to the general course of the muscle fibre. Each of these nerve-fibres is completely enveloped by the minute blood vessels which run parallel with them. This admirable arrangement of the capillaries yields the abundant supply of bright arterial blood, so necessary for the manifestation of muscular motion; as contractions evidently ensue from changes taking place in the material in, of, and about the ultimate fibre by a nervo-voltaic process.

Fig. 5. A View of the Minute Structure of the terminations of all Nerve-Fibrils, both to the skin, in the muscle fibres, and in the brain substance.*

*Termination of Nerves in the Voluntary Muscles of Man.*— Every elementary muscular fibre is abundantly supplied with nerves, which form a network and lie upon the surface of the sarcolemma of the fibre without penetrating it. The fine twigs of muscle-nerves run parallel, close to the smaller arteries and the capillary vessels. The nerve-fibres in muscles, and in other tissues, may be traced into, and are continuous with, a network formed of oval nuclei and intermediate fibres. These little oval nuclei are the true agents in the development of nerves and the

* 1. The mode of termination of nerve-fibrils in loops: three are seen to be simple; the fourth is convoluted. The latter is usually found where an exalted degree of *sensation* exists. But most nerves terminate with free ends.

2. A nerve-fibril from the brain, showing a varicose appearance, which is possibly produced by traction or pressure.

3. A nerve-fibril highly magnified to show its structure — a tubular form containing the *neurine mass*, consisting of cells embedded in soft granular material, which appears to serve as a simple bond of connection between them. These cells, says Dr. Druitt, vary in size from one one-thousandth to one five-thousandth of an inch in diameter. They are of a reddish-gray color, and are composed of a capsule containing a granular pulp and a true nucleolated nucleus that is adherent to the inner surface of the investing capsule. The contents of the nucleus are similar to the contents of the parent cell.

4. A nerve-cell, highly magnified, showing its composition.

5. Shows its nucleus to contain a *nucleolus*.

6. A nerve-cell from which several *caudate* processes are given off. Nerve-cells are mostly globular, but some are oval.

7. Shows the *third* constituent of the medullary masses, mere granules, or still more minute cells; these, in the cerebral fibres, are in greatest numbers, of different sizes and often nucleated.

formation of new fibres — the organs by which nerves communicate with other textures. Whenever there is exalted nervous action, then will these oval bodies be associated in great numbers, while where there is more moderate nervous action they are found in less numbers; so when their presence is in a still smaller proportion it indicates that the nervous phenomena are only imperfectly performed. The manner, too, in which the nerve-fibres are connected with the network of the small oval bodies and intermediate fibres, suggests that an impression made upon a given portion of a sentient surface might be transmitted to the nerve-centre by contiguous fibres as well as by the one which answered to form the shortest route; and that it is possible that impulses to motion may be conveyed to muscular fibres by a more or less circuitous path as well as by the direct route.

As the nerve-trunks approach their distribution, each individual fibre divides and subdivides, and the fibres resulting from this subdivision often pursue a very long and complicated course, running parallel, for some distance often, with other fibres derived from different trunks. Fine trunks, composed of from three to seven or eight fibres, can often be seen traversing the muscle within the field of the microscope. The fibres pursue different directions: some dip down between the elementary muscular fibres; some pass over the surface, and form with others, from a different source, small compound trunks; while others may be traced onwards for some distance. The finest individual fibres, which gradually separate from each other, are distributed to different parts in succession. When the finest nerve-fibres can be seen passing round the elementary muscular fibres, they consist of most delicate, flattened ends.

The arrangement of the network of fibres connecting the Pacinian oval bodies, or nuclei, — which are the terminals of branches, and, of course, continuous with the subdivisions of the last nerve-fibrils, especially as to the number of the nuclei and their proximity to each other, — differs materially in different localities. On sentient surfaces, according to Dr. Beale, the meshes are very small, and the nuclei are close together, and the network is imbedded in most cases in the midst of fibrous

tissue. The tubular membrane is a transparent structure in which the nerve-fibres are imbedded, and often it is thicker than the fibres it contains. If we examine it with high powers, say two thousand times, (seven hundred diameters,) many fibres which appear to be single when seen by lower powers can be resolved into three or more, all enclosed in the same transparent tissue. As the nerve-fibres approach their distribution, this transparent structure becomes much spread out. It is intimately connected with nerve-fibres and capillaries, and with them forms a delicate expansion over the muscular fibres and in other parts. Other delicate fibres, also, in connection with the nerves and capillaries, may be observed in it. In some cases this expansion seems to be incorporated with the sarcolemma, and it is in certain instances, probably, the real structure which receives that name.

*Oval Bodies*, or *Nuclei*, are connected with all nerves, *sensitive*, *motor*, and *vascular*, in every part of the body in man. From these nuclei new branches are developed. Thus the nerves multiply at their distribution by the division of these little bodies; and upon them, in all probability, the manifestation of nervous phenomena depends. They are found very freely connected with vascular nerves, and are abundant in those nerves near the ganglia from which they proceed, and in the ganglia themselves. Late authorities believe that the gelatinous fibres, or fibres of Remak, are, after all, real nerve-fibres, and not a peculiar modification of fibrous tissue, as was generally believed. Thus we have seen, in connection with the terminal ramifications, new fibres are being continually developed by the division of the nuclei, the old ones undergoing removal. The remains of the latter, says Dr. Beale, may sometimes be seen in the appearance of very delicate fibres in connection with active nerve-fibres; and he regards much of the so-called connective tissue between the elementary fibres of muscles, and in some other situations, as of this nature, — as the remains of structures whose period of functional activity was past, and which have been already removed, with the exception of this small quantity of less soluble matter.

Thus it is shown that every elementary fibre of striped muscle is abundantly supplied with nerves, and that the fibres of some muscles receive a much larger supply than others; that the nerves lie, with the capillaries, external to, but in close contact with, the sarcolemma, or covering of each ultimate muscle-fibre, while there is no evidence of their penetrating into the interior of the fibre. These final twigs of nerve-fibres often cross the muscle-fibres at right angles, so that one single nerve-fibre may influence a great number of elementary muscular fibres; that each nerve, of whatever nature, takes origin from a nerve-cell in the central nervous organs, and terminates at the periphery, or in the interior of an organ, (1) either in a nerve-cell, and, in the case of nerves of sense, *in* the nucleus itself; (2) or in the mass of a cell, as in the interior of organs in the case of the ganglionic nerves; (3) or, finally, by forming a nervous capillary network where the anatomical differences disappear, the axis cylinders passing from the one into the other.

Hence we see that the nervous system, central as well as peripheral, forms a whole, which, like the circulatory system, pervades every portion of the organism, penetrating across different parts, and arriving at the ultimate elements without at all being lost in a vague or confused manner; that the nervous elements, the cellules as well as the axis cylinders, are always in course of development, or, by replacement, in the central organs, as well as in the muscle-tissue, and at the sentient periphery; that the part performed by the cellules varies, for they either preside over special functions, in special parts, as in the case of the organs of sense, or subserve the preservation of all the central and peripheral organs themselves, as in the case of the glandular and nervous organs; that the physiological functions of the organs arise from the perfect and harmonious connection of these nervous cellules with the central nervous system.

*Law of Nerve-irritability.* — Until very recently, it was supposed that the irritability of a point on a fresh nerve is greater the nearer the point is to the muscle in which the nerve is distributed. By the nicest possible physical experiments, there is

made out the following law: "One and the same irritant, which is applied successively to two different points of a nerve, does not irritate the muscle in the same degree; but the excitant which is applied at the greater distance from the depending muscle acts the more powerfully." It is supposed by Pfluger that the excitation increases in an avalanche-like manner, and that this is the more considerable the greater the portion of nerve over which it travels.

As in the law of nerve-excitation, so here, the only objective sign by which the irritability of the nerve-fibre can be measured is the degree of muscular contraction obtained under given circumstances. In the living nerve, three conditions are requisite for the maintenance of its irritability or functional excitability: —

1. *Connection* with the nerve-centre.
2. *Nutrition* by arterial blood.
3. *Activity* or repeated interruptions so as to prevent total rest.

*Laws of Nerve-irritation and Muscle-contraction.* — The conditioning circumstances of muscle-contraction, which is also evidence of nerve-action, produced by natural or artificial electricity, are, —

1. The law of Dubois Reymond, namely, "The excitation of a nerve is not produced by any given strength of electric current of unwavering magnitude, but *by changes* produced in the given magnitude — in the strength of current — from one moment to another."
2. The existing degree of irritability of the given nerve.
3. The direction of the current.
4. The strength, variation, interruption, and sudden reversion of the current employed.

When the nerve of the prepared limb of the living frog is submitted, in part of its length, to the action of a constant primary current of electricity, a muscle-contraction instantly follows upon closing, and again as promptly on opening, the galvanic current. In the interval, the muscle remains in a state of relaxation, although the current is all the while running through the nerve. Now, if, in this interval, the current be *gradually* increased, or *gradually* diminished, still no contrac-

tion takes place; but if the current be *suddenly* increased or diminished, interrupted or reversed, then contractions promptly follow. And if these sudden variations are continued in a rapid succession, then there will be maintained a continuous contraction — *tetanus*. But the effect on the nerve so treated will be in accordance with the *method* by which the current was changed or deviated.

On applying a current to a nerve, we produce in it a sudden elevation of electrical tension, a positive variation of the nerve-current; and on opening the current, — that is, on taking it away, — a sudden depression of tension, a negative variation, is produced. Thus both cause contraction of the muscle, because each fulfils the conditions of nerve-excitation by changing, at a certain velocity, the internal molecular polarity or condition of the nerve-trunk. It is found, also, under certain conditions, that very powerful constant currents produce a series of contractions which continue during the application of the current, and even after it is removed. Dubois Reymond ascribed this result to an abusive or a destructive influence on the nerve, producing an electrolysis in its structure. But M. Pfluger, in his recent great work on this subject, has discovered some entirely new facts which render a modification of these views necessary. He has made numerous experiments on living nerves, with very weak, and very strong currents, and with every varying strength. It would appear that a constant galvanic current, within a certain range of strength, and that a low one, has the faculty of producing, not destruction, but *physiological changes* in the molecular constitution of the nerve, which lead to a continuous contraction of the depending muscle, and a more or less abiding influence in the nerve.

*Effects of Electric Currents on the Functions of the Motory Nerves.* — Here no law could be said to exist until the appearance of the work of Pfluger. It is said that a muscle contracts, momentarily, on closing and opening a primary current. Now, if this were invariably true, under all circumstances, the law of muscle-contraction would be a very simple one; but we have shown that Nobili, Ritter, Pfaff, and others, endeavored to deter-

mine the cause of the appearance of the contraction in one instance, and not in another. They found that among the conditioning circumstances were, first, the degree of irritability in the nerve tested; second, the direction of the current. But they did not take into the account the strength of the current employed. Pfluger and Heidenhaine have recently discovered, almost simultaneously, that the strength of the electric current is most material to the result. In the work of the former, at page 454, may be found the law of contraction in the fresh nerve, which he defines as "*the function of the strength of the current;*" and he distinguishes three degrees of this strength. The following table expresses Pfluger's law of contraction through the nerve-trunk: —

| Strength of Current. | Centripetal Current. | Centrifugal Current. |
|---|---|---|
| With *weak* current, | closing — contraction; opening — rest; | closing — contraction. opening — rest. |
| *Moderately* strong current, | closing — contraction; opening — contraction; | closing — contraction. opening — contraction. |
| With *strong* current, | closing — rest; opening — contraction; | closing — contraction. opening — weak contraction. |

It need scarcely be said that by *centripetal* is meant a current running *from* the muscle *towards* the spine and brain; by *centrifugal*, a current running *towards* the muscle *from* the cord and brain. These observations were made with most refined instruments, and with greatest care; and, having ourselves witnessed the experiments of Professor Pfluger in the University of Berlin, Prussia, we can bear testimony to the accuracy of his electro-physiological trials. Similar testimony may be seen in an able review of this work in the British and Foreign Medico-chirurgical Review for 1862, from which we shall also quote.

The explanation of the foregoing facts, as well as "the theory of the law of contraction," is founded upon a knowledge of the changes of irritability *produced* in a nerve by the action of a certain primary current. When such a current is passed along a portion of a nerve, a change of irritability takes place both between and for some distance outside or beyond the site of the electrodes. Under and in the neighborhood of the *positive*

*electrode*, whether of sponge or metal, there is produced a *decrease* of nerve-irritability; while under and in the neighborhood of the negative there is produced a diminished irritability of the nerve; and this, in degree, in proportion to the strength of the current, and the time it is continued, in both instances. This is a very fundamental *law*, and must be observed in practice.

Again, the relative extent of the two zones of irritability, the one plus, the other minus, also varies according to the strength of the current employed, so that with a moderate current almost the whole of the intra-polar tract is in a condition of exalted impressibility, termed *irritability*. Dr. Pfluger designates the condition of increased action at the negative electrode (*Kathode*) "Katelectrotonus;" that of diminished irritability occurring at and about the positive electrode (*Anode*) he terms "Anelectrotonus."

It is also found that the *conducting power* of a nerve is altered under these circumstances, and in such a manner that the anelectrotonic part is rendered *unfavorable*, while the katelectrotonic *is rendered more favorable* for conducting nerve-irritation.

Dr. Pfluger discovered that "one and the same irritant applied at two different spots on a nerve-trunk does not contract the muscles in equal degree, but so that the irritation acts most powerfully the further removed the spots of application are from the depending muscle." Thus "the law of muscle-contraction," when summed up in Pfluger's own words, is, "A given tract of nerve is irritated by the constitution of katelectrotonus and the disappearance of anelectrotonus, but not by the disappearance of katelectrotonus and the constitution of anelectrotonus." (p. 456.)

In other words, this rule implies that in passing a primary current along a portion of a nerve, the irritation, *on closing* the circuit, takes place at the *negative* electrode; *on opening* (*breaking*) the circuit, it takes place at the *positive* electrode. Thus, viewed by the light of this law, the phenomena of the law of contractions are easily explained. Let us take, first, the centripetal current as shown in the foregoing table. With a weak

current, a contraction takes place on closing the circuit, which afterwards, with a stronger current, does not appear. Why? Irritation of the nerve is produced by katelectrotonus in the portion most distant from the muscle, and above the anelectrotonus part of the nerve. With a certain strength of current the latter part of the nerve becomes so diminished in irritability that it fails to conduct the irritation from above it, i. e., in the region of katelectrotonus, to the muscle below. The opening contraction occurs with a stronger current, and is caused by the disappearance of anelectrotonus when the circuit is opened. The reason that it occurs later than the closing contraction, is, that, in conformity with the law above given, a point of nerve is more irritable the greater its distance from the muscle; besides, the disappearance of anelectrotonus is found to be in itself a less powerful stimulant than the production of katelectrotonus. The same rules as easily explain the phenomena by the centrifugal current. With a weak current, a contraction occurs first on closing the circuit, because the katelectrotonus portion is next the muscle. The opening contraction *may* sometimes occur *before* the closing contraction, because the irritation (caused by the cessation of anelectrotonus) acts upon a higher and more irritable portion of the nerve. That the opening contraction should diminish and disappear before the closing contraction is thus explained: On opening the circuit, the irritation at the anode must pass along the intra-polar portion of nerve, as also the part which has been in the katelectrotonus state. Now, this portion of the nerve, on opening the circuit, falls at once into a state of depressed conducting power, and is unable to convey to the muscle the irritation produced by the disappearance of anelectrotonus. Such are the facts, and such the explanation of the phenomena which follow exact electric irritations of the motory nerves.

*What is the Law of Nerve-excitation in the Sentient or Sensitive Nerves?* — Is there any difference in the phenomena resulting from the excitation of a sensitive and a motor nerve? Assuming that the functions of these two grand classes of nerve-fibres are different, so, in order to serve physiological purposes,

the plan of excitation must necessarily be different; and we find the results are also different; while the phenomena of molecular action, so far as the fibres are concerned, appear to be precisely the same. But this is obviously a much more difficult inquiry with sentient nerves than in the case of the motor nerves, where we have degrees of muscular contractions, as an objective result, capable of being accurately measured. The following experiment by Pfluger renders it probable that in sensitive nerves the law of excitation is analogous to that of the motor nerves.

"A frog was poisoned with strychnine in order to increase its susceptibility of reflex movement, and so fastened as to avoid disturbance of every kind. Previously, the sciatic nerves had been isolated, and all the textures of the upper part of the thighs divided, so that no connection existed between the upper and lower part of the limbs, except through the large nerves. The electrodes being now carefully placed on the nerve-trunks, a strong centrifugal primary current was applied. On closing the circuit, contraction of the legs only occurred; on opening it, *no* contraction of the limbs, but strong reflex convulsions of the whole body of the frog. With the centripetal current the results were reversed — reflex convulsions being present on closing the circuit, but absent on opening it."

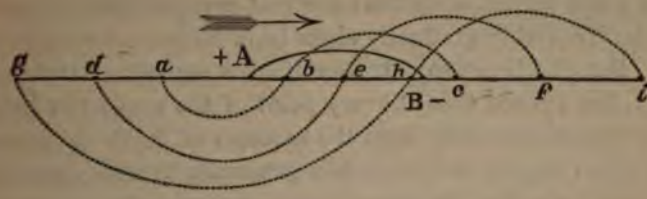
These facts would seem very clearly to prove that in the sensitive nerves the cause of irritation is the same as in the motor, namely, the constitution of katelectrotonus and the disappearance of anelectrotonus. Of course, as the results are manifested in opposite directions, we must expect, what the above beautiful experiment proves, the inverse sequence of phenomena from the two different directions of the current. That is to say, in the sensitive fibres we should expect, and we get, the same phenomena from the centripetal current, as, in the case of the motor-nerves, would occur from the centrifugal current; and *vice versa;* for we must bear in mind that there are scarcely no *purely* sensitive, or motor, nerves; but nearly all, if not quite, are more or less compound, as some few filaments of the one are found bound up with those of the other in all nerve-trunks, excepting a short distance of their immediate origin from the spinal cord.

What are the proofs of the special modifications of irritability during and after the electrotonic state, i. e., during and after the application of a given voltaic or galvanic current?

*The great general law of nerve-irritability*, according to Pfluger, is, that when a centrifugal primary current is passed along a nerve, a *change* of excitability is produced, not only in the portion traversed by the current, but also *before* and *behind* it; so that in the neighborhood of the negative electrode (kathode) there is an exaltation, in the neighborhood of the positive electrode (anode) there is a depression, of the nerve-irritability. The former condition (katelectrotonus) takes place in the extra-polar part of nerves *before* the current; also in that part of the intra-polar tract next to the kathode; the latter condition (anelectrotonus) takes place in the extra-polar tract immediately *behind* the current, and in that portion of the intra-polar tract next the anode. The extra-polar anelectrotonus and katelectrotonus are termed *centripetal* when they extend from the electrodes towards the central end of the nerve, and *centrifugal* when they extend towards the muscle. The point at which the two zones of modified irritability meet is called by Pfluger *the point of indifference*. But we must bear in mind that various circumstances influence the degree of anelectrotonus and katelectrotonus, as,—

1. The strength of the current employed.
2. The distance of the part of the nerve the irritability of which is being tested from the electrodes.
3. The length of the tract of nerve traversed by the current.
4. The length of time the current is applied, as also the repetition of the trials, and existing fatigue of the nerve.

*The Contraction-law.* — We must keep in mind *that the irritation of a nerve and muscle, on closing a circuit, takes place more at the negative pole; on opening a circuit, more at the positive pole.* Of course we refer to the action of the primary current of galvanism, which is to be always understood as the form of electricity employed for making nice electro-physiological experiments. By observing, and accurately estimating, the effect of one or many interruptions in this current, at the positive and negative poles, we may calculate the accumulated effect of the interrupted current of induction.




The above diagram, familiar since the work of Funke, will illustrate the first two of these conditions. Suppose the straight line to represent a nerve-trunk, and the points A and B to be the positive and negative electrodes of a constant primary current, placed so that the tract A B is traversed in the direction of the arrow — centripetal or centrifugal, as the case may be. If we now examine the irritability of different portions of this nerve while weak, moderate, and strong currents are passed along it respectively, and represent the effects by dotted curves, we shall obtain with weak currents a curve such as *a b c;* with a medium current, the curve *d e f;* and with a strong current, the curve *g h i.* Again, let us examine the curve *a b c.* We find that the change of irritability in the extra-polar portions *a* A and B *c*, and in the intra-polar portion A B, consists in an elevation of irritability over the part *b c*, and a depression of irritability over the part *a b.* The point *b*, at which the dotted curve crosses the nerve line, is the *point of indifference* at which the two zones of modified irritability meet. If we compare these three curves, it appears that, with weak currents, almost the whole of the intra-polar tract has its irritability increased; with medium currents, the zones of altered irritability extend over a greater tract of nerve, are greater in intensity, and are almost equally divided in the intra-polar tract. A still stronger current produces greater intensity and extent of altered irritability, and the zones are so adjusted under this influence that the point of indifference is nearer the *kathode*, (negative electrode,) and the intra-polar tract is almost entirely in a state of diminished irritability.

*What is the Phenomenon of a Dying Nerve?* — Until very recently it was supposed that in a dying nerve, i. e., in a nerve

from which nutrition and the cerebral nervous influence are cut off, the irritability gradually sinks from its normal state to nothing. But this is not so. J. Rosenthal, a student of Dubois-Reymond, has proved that at every point of the nerve the irritability *increases* decidedly from the moment of death or severance to a given degree, and then falls gradually to zero; and this is the result whether the nerve is cut out to die alone, or remains in connection with the spinal cord and brain to die with the whole body. The following table will show concisely the law of muscular contraction in the dying nerve: —

| State of the Nerve. | Centripetal Current. | Centrifugal Current. |
|---|---|---|
| In the first nerve, | closing — contraction; opening — rest; | closing — contraction. opening — rest. |
| At a later period, | closing — contraction; opening — contraction; | closing — contraction. opening — contraction. |
| Still later, | closing — rest; opening — contraction; | closing — contraction. opening — rest. |

Much research has been bestowed upon disease and disuse of nerves, yet it is undetermined whether, in the regeneration of nerves, the old nerve-sheaths fill again, or whether entirely new fibres are formed. On cutting through a nerve where there is fatty degeneration, we find it occurs in the peripheral portion, and is probably due to the *want* of some influence from the nerve-cell, or from a part close to the anterior roots. As in the case of other tissues, physiological activity is necessary for producing the peculiar chemical changes for electrolysis and catalesis; or, in other words, for depuration and nutrition.

*Nerves in a wound healed either with their fellows, or to other nerves, prove the same conductibility of different kinds of nerves.* During the past year or two, most intricate and delicate experiments have been conducted by Drs. Gluge, Thiornesse, Philipeaux, and Vulpian, to ascertain by actual demonstration the effects obtained by the *reunion of the divided ends of nerves, possessing different functions.* The trials were chiefly made upon dogs. It was observed that full-grown and older animals bore the operations better than the younger ones. When the peripheric end of one nerve of mixed function is joined, in a wound, to the cen-

tral end of another mixed nerve, intimate union takes place between them. A similar junction occurs when the centric end of a sensitive nerve is placed in contact for healing with the peripheric end of a motor nerve. Under the influence of the anatomical and physiological conditions thus produced by the experiment, the peripheric end of the motor nerve, which in the first instance undergoes partial degeneration, becomes throughout its whole length completely regenerated.

The reparation which takes place in the peripheric end of a nerve, allowed to lie loose in the tissues of the wounded part, is ordinarily very imperfect, at least for several weeks or months; while the regeneration of the peripheric portion of a nerve, when placed in apposition with the centric end from which it was severed, or with a centric end of some other nerve, is much more perfect — complete regeneration of all the nerve-tubules appearing to take place; and it is more rapid, even, if it be a nerve of different functions. Hence it would appear *that regeneration is hastened by an influence proceeding from the centres;* and it seems to be of no consequence whether this centrifugal influence passes through the centric end of a motor nerve or of a sensory nerve.

When the union is perfect, and the regeneration of the peripheric end is sufficiently advanced, stimuli of touch or electricity, applied to one of the ends, can be propagated through the junction to the other. This effect can be most distinctly shown when the peripheric end is motor, for it is possible to excite contractions by the application of stimuli to the sensory nerve above the cicatrix in the muscles supplied by the peripheric extremity of the motor nerve. Strong contractions of the muscles of the tongue can thus be induced either by mechanical or electrical excitation of the centric extremity of a pneumogastric or lingual nerve united in healing to the peripheric extremity of a hypoglossal nerve.

By establishing a similar union between a cerebro-spinal nerve and a sympathetic nerve, movements can be excited in the parts supplied by the latter, in consequence of irritation being applied to the former. The galvanization of the peripheric end of a

hypoglossal nerve, that has been united by operation and healing with the upper end of the cervical sympathetic nerve, produces all the effects upon the eye and pupil which characterize the stimulation of the original nerve-root. Moreover, the changes induced in any part of such tested nerve can be clearly shown, by actual demonstration, to be propagated centripetally, as well as centrifugally, whatever may be the function of the nerve.

The highly-important results of these trials show us that nerves are motor or sensory, not by virtue of any power inherent in themselves, but simply as the result of their centric and peripherical relations. "They must be regarded, therefore, as excitable cords," capable of being polarized in either direction, and hence capable of conducting, or transmitting, irritation in one direction or the other, whatever may be their relation, and whether they belong to the nerves of animal or of organic life.

### *Electro-Physiological Researches and Creeds.*

We said in the chapter of history that Volta objected to the theory of Galvani; but, at the same time, we find he took up these nervo-electric phenomena, first discovered by Galvani, as a nucleus of vast significance; and he, therefore, made them the subject of his most rigid investigations up to 1800. First, we see, it was reserved for him to show that the metal arc employed by Galvani to produce the muscle contractions was not a simple *conductor*, but as being in and of itself a source of electricity, because it consisted of two dissimilar metals. From this stepping stone, placed for him by Galvani at first, Volta becomes the discoverer of the *electric pile*, which bears his name, and also the author of the *contact theory*. After this, the great object of his life seems to have been to show the correspondence in every particular between the *contact current*, as he then termed it, and the electric current, obtained by the friction machine, then already so well known. There were, however, those who doubted. In this connection, we may see motives which lead Volta to seek to prove, by every possible means, "the identity of the electric and galvanic fluid."

Volta also endeavored to remove all those theoretical difficulties which were presented, arising from the steadiness of the working of the closed pile, as it was then understood. Although uninterrupted chemical workings, as the decomposition of water, for instance, was very probably known to him, yet when referring to the action of the current *in the living body*, he says, "Only within certain limits, the definition of which would be difficult, does the continuous working of the current on the organs become at rest; for the minute shocks, or blows, which are like rapidly repeated sparks, following one another almost, if not quite, without interruption, in some way or another mingle into one single prolonged blow, as, indeed, I have heretofore tried to explain."

In the above quoted passage, evidently Volta advances the idea that the contact, or first flow of a current from a closed circuit of a voltaic pile, consisting say of one hundred pairs, is not simply and absolutely one blow or shock, but is an impression made *as one* out of one hundred blows or shocks, which follow each other so rapidly, yet in actual succession, that they mingle together *as* one shock.

In a letter to the Right Honorable Sir Joseph Banks, which is found recorded in the Philosophical Transactions, London, 1800, Dr. Volta says, that when he introduced the poles of a pile of thirty to forty pairs into the external opening of his own ear, he felt a shock to his head, and some moments afterwards he heard a sound, or rather a noise, like scratching and bubbling, or like that of a viscid substance boiling. This noise was continuous and without interruption, becoming even more and more intense until the circuit was broken."

It was the muscle contractions that were observed at the closing and opening of the circuit, and particularly the latter, that attracted the greatest attention from Dr. Volta. He erroneously supposed the latter to be due to a sort of counter-current from a kind of induction, that flowed back on the instant of opening the circuit. M. Lehot, in 1801, modified this theory of Volta's, by laying down the proposition, that during the passage of an electric current through a nerve, a part of the

*accumulated* electricity in the nerve and muscle, at the interruption of the continuous current, flowed at that instant in the opposite direction to which it entered, and so giving rise to the contraction, the same but in less degree as when the current was first closed. This was also erroneous. But the illustrious physician and philosopher Volta gave to these phenomena the term "*opening and closing convulsions*," and which are often found referred to by writers. It was Dr. Luigi Galvani, of Bologna, who first discovered that kind of contraction of the muscles of a frog that constitutes the *closing convulsion;** while it was Dr. Valli, another Italian philosopher, who soon afterwards made the discovery of the *opening convulsion.*† But after all, we can go a long way back of all this to find *the first tangible case recorded of the physiological effects of galvanic electricity;* for, in a paper published by M. Sulzer, in the Reports of the Berlin Academy of Sciences, in 1754, he says, "If a piece of lead and a rod of silver are connected with each other, and approximated to different parts of the tongue, a sensation of taste is experienced which resembles that produced by the vitriol of iron; while, *if we employ either of the metals alone, not the slightest taste is perceived.* It is probable, therefore, that *by the connection of the two metals*, a vibration is produced in the smallest particles, either of the lead, or of the silver, or in both of them; and that this vibration, which must necessarily affect the nerves of the tongue, produces the taste described." It was received as a curiosity.

The first systematic work upon *medical electricity*, including the employment of galvanism, was from the pen of a German physician — Dr. Grapengiesser, of Berlin, in 1801. It appears that his work was not the mere production of theory, but was "the result of his practice," and more particularly of the considerable success he obtained. He advises the employment of the voltaic current of electricity in amaurosis, and in cases where there is a premature decline of vision from want of nerve power — for tumor albus, for rheumatisms, for sciatica, and for palsies.

* De Viribus Electricitatis in Motu musculari Commentarius. Bologna, 1791.
† Reinhold, Geschichte des Galvanismus, etc., 1792.

In these latter affections, *it was his practice* to place the *positive pole* over the trunk of the nerve that supplies the affected muscles, while the negative pole is placed lower down on those affected muscles; thus he employed mostly the continuous voltaic current with *rare* changes or interruptions. He also speaks of using it successfully in deafness, and in hemiplegia, *after the cessation of the pressure in the brain*, and in all other paralytic affections and conditions. He seems to have resorted to a species of reflex action; for he speaks of using wooden basins filled with water, into which the electrodes, together with both the feet, or the two hands, of the patient are plunged. Of course, one limb receives the negative current as up-running, while the other limb is receiving the current down-running towards the positive pole to form the circuit; and these he *alternated* according to the case.

His general method, in nearly all other cases, seems to have consisted in drawing two blisters, and applying and retaining a single pair of silver and zinc plates *immediately upon these raw surfaces*, the cuticle being first removed. This, indeed, had been recommended, by Alexander von Humboldt and others in those times, as the most direct and effective method of using galvanism; and certainly it was a "localized method" with a severity, for we also see mention of "several hundreds of pairs of plates" in the pile employed, and also of "a hundred blows given at a *seance*," by the opening and closing of the circuit, through these *raw surfaces*.

There was another work, published by Dr. Richard Fowler, on "Experiments and Observations relative to the *Influence* lately discovered by M. Galvani, and commonly called *Animal Electricity*," in Edinboro', 1793. This English work contains very many curious and also interesting facts, showing how the case appeared at a distance in those earlier times of its history.

Still another work may be mentioned, among the many that were put forth in England, which was by Dr. Wilkinson, in 1804, entitled "Elements of Galvanism," which contains much good hard sense in connection with this subject. Dr. Wilkinson found

that two pieces, one of silver and the other of zinc, each presenting a superficial surface of only a hundredth part of an inch, produced violent contractions in the leg of a frog prepared after Galvani's method. At the same time he found that two circular plates of zinc and copper require to be brought twenty times in contact with the condenser of the best electrometer then to be had, before any sensible divergence of the gold leaves of that instrument was produced. By comparing the area of these plates, multiplied by the number of contacts, with the superficial surface of the minute pieces of silver and zinc employed to effect the muscular contraction of the leg of the frog, he arrived at the conclusion that the sensibility of the fresh-killed frog to electric currents is many thousand times greater, — or, in other words, more delicate as a test of electric currents, — than any of the most sensitive electrometers.

It is worthy of notice, also, that the earliest and most distinguished observers of these electro-muscular contractions mention the fact that the convulsions, as they were usually called, were more promptly and strongly produced *after* a certain number of electric treatments, — and that by means of only a single pair, — than they were when first applied; and that all the more marked if a moderate current was employed than when a very powerful current was used. Alexander von Humboldt made analogous observations from *ad hominem* experiments which he caused to be conducted upon his own shoulders. After having removed the cuticle on each shoulder by means of a cantharides plaster, and exposed these raw patches to the *immediate* action of a pair of silver and zinc plates, he speaks of the effects in this manner: "As torpid or long-dead frog-thighs, *at the commencement* of galvanizing, twitch hardly any, if at all, but, after being brought for the third or fourth time in contact with the electrodes of a closed chain, the twitchings become lively, just so have I observed distinctly on myself that the first blows or shocks of a moderate current produced only a dull sensation, which, however, was perceptibly increased in degree, so that, from the fourth to the sixth contact of the connecting wires, they were of greatly augmented force. Does here the stimulus

itself increase the excitability of the organs so that by the fourth to the sixth blow, while the irritation remains the same, the *susceptibility* is become increased, or is the excitability not exalted, but, on the other hand, is the irritation aggregated in the muscle fibres? Of these two suppositions, I am inclined to think the first as the most probable."

Immediately after these declarations, M. Ritter, first of all,* by experiments observed that the closed chain does, indeed, alter the excitability of a nerve and muscle; for a steady current traversing a prepared leg and nerve of a frog, either through the nerve alone or through the nerve and muscles both, and for a long time, — say from half an hour to an hour, — will exercise an influence to change or decrease the irritability, so far as it shows itself by opening or closing convulsions. But the *direction* of the current employed produces very different results; and that, — namely, the down-running if a continuous current, — renders the thigh of the frog, in the course of an hour, incapable of showing either closing or opening convulsions, if the same direction of the current is used; but by then using the up-running current, there will not only be produced, (after a half hour, or even whole hour,) at the opening of the chain, very strong twitchings, but it will even afterwards occasion tetanic contractions, which can also be dissolved again by closing the chain. Thus two frog-thighs may be treated simultaneously in the same manner, but the current must be running up in one while it is running down in the other: now, if these are alternately changed from hour to hour, — i. e., simply reverse the direction of the current, — each of them may be put in the same condition in which the other was the hour before; and these alternations can be proceeded with for a whole day, or until the excitability gradually decreases away. Again: if both arms of a person are exposed to a *powerful* current, and for a long time, — say half an hour or so, — there will be experienced, in the one in which the current runs up, a feeling of increased mobility; while in the other, where the current runs down, there will be a sensation

* Beweis dass ein selbeststandiger Galvanismus, etc., Weimar, 1798.

of heaviness or lameness felt. M. Ritter afterwards corrected these propositions by saying that the exaltation caused by the up-running current does not always appear, but only now and then, as when weak currents are employed, but never when strong currents are used; and after employing a powerful current for a long time in either direction, there will be produced a depressing influence — i. e., as a general thing, make the excitability of a muscle or muscle-nerve thus traversed for a long time to decrease faster than would take place in the already dead frog if left to itself.

It must be borne in mind that the above statements, and also the corrections, all date from a time when M. Volta had already published his observations on the alternated actions of the current, and which he had reached by quite another process. These facts I record because "the alternations of Volta" and "the alternatives of Ritter" are so frequently referred to by the older writers in this department of medical literature.

Soon after Galvani's classical experiment (see page 72) had been made known, Dr. Volta was the first to notice that the electro-muscular contractions take place, if only a *portion* of the nerve is alone enclosed in the circuit, not transversely, but *lengthwise*, and that without touching the muscles with the electrodes, or even including them between the poles of the circuit. This led to a flood of trials, which were immediately instituted by Volta, Ritter, Pfaff,* Lehot, Humboldt, Valli, and Galvani; and then, still later, by Nobili, Marianini, and Matteucci; and then, again, more recently, by Dubois-Reymond, Faraday, Marshall Hall, Becquerel, Duchenne, Todd, Bird, Remak, and Althaus. The larger class of those early experiments was directed mainly to ascertain *the law of current direction* and *the law of muscle contraction* or *convulsion*.

It was very soon observed that the nerves of the batrachian tribe, — those famed martyrs to science, — were so sensitive to the electric stimulus that *only* the more gentle currents of the pile could be employed; for if the current was strong, whether

* Uber thierische Electricital und Reizbarkeit, Leipzig, 1795.

up-running or down-running, the commotion was so great that the real difference could not readily be observable. M. Pfaff early drew attention to the particular difference in the phenomena that presented on running a mild current *up* or *down* a nerve; for if the current of a powerful pile be used, no such differences would be uniformly observed. But by using the current of a single pair of steady and continuous action, we observe the following: Where the frog is vigorous and but recently killed, and the nerves of the prepared legs are consequently in the highest degree of excitability, we usually see contractions both at the closing and at the opening of the circuit, and that whether the current runs down or up. But if, after a longer time, or by repeated teasing with the galvanism, the legs and nerves have lost a part of their excitability, then a very marked difference is noticed in the physiological effects. Now, if we first direct a down-running current through the ischiatic nerve, the contraction, which is a mere momentary twitch, is observed *only at the first moment* the current is applied, but not while the current continues to traverse the nerve, nor yet at the moment when it ceases to pass. But if an up-running current be applied to that nerve, with say a half-inch space between the poles on the nerve, just as in the former case, we observe there are *no* contractions at the first moment the current is applied, nor yet while it continues to traverse the nerve, but *only* at the moment when the circuit is broken, and the current *ceases* to pass.

Again: if we employ in these researches the united pair of legs of a frog prepared after the original manner as done by Galvani, and immerse the two legs respectively in two glass vessels which are nearly filled with water, and now plunge a pole of a weak current into each of these vessels, we notice that contractions do not take place in each at the same time, provided, always, that the legs have lost some of their excitability, so as to make the differences more distinctive. Now, a contraction will be observed, on *making* the circuit, in that leg in which the current is *direct* or down-running; but it will be on *breaking* the circuit in the other leg in which the current is *inverse* or

up-running. Then, if the irritability in the preparation be allowed to be still further diminished by time, or by treatment for experiments, only one kind of contraction will remain, namely, that first produced by *making* the direct current at each time; if the irritability be still further diminished, all contractions or twitchings of any sort whatever will disappear.

If a gentle, continuous current be applied to a nerve, the nerve will retain its excitability very long, — i. e., to the touch of a reversed current, — and will not be injured as much as is done by applying moderate mechanical or chemical stimuli. But if the continuous current be of great *quantity* or *high* intensity, — if, instead of a single battery, there is employed a large size series, or if, instead of a single pair, there is employed a numerous pile, — then, just as we might expect, the nerve will be destroyed by the chemical action at and about the electrodes.

Finally, as I have said, Nobili gave these differences of contractions, which so elicited the early attention of philosophers, a most elaborate series of investigations. He concluded, finally, that there were *five* different stages, kinds, or *degrees* of contractile *response*, in nerves and muscles, to the same given strength of electric current. But we now conclude that some of those differences that he found, arose from experimenting on *dead frogs*, not on living animals or men, and that the difference in results obtained in those early times, by equally honest experimenters, mostly arose from using widely different electric apparatus and currents, as to *quantity*, *intensity*, or the given *density* of the stream employed.

M. Matteucci not only corroborated from his researches the "*current proper in frogs*," noticed by Nobili, but also discovered and demonstrated in man, and all warm-blooded animals, *the existence of a natural muscular electric current.* By cutting the muscles of a living animal, and thus introducing into the wound the nerve of the fresh prepared *frog-galvanoscope*, so that the end of the nerve touched the very bottom of the wound, whilst another point of the same nerve touched only the edges of the wound, he obtained a decided contraction. This, he says, was fair proof of the existence of a natural electric cur-

rent, directed in the muscles from the deep interior of their body to the surface. This experiment we have often seen succeed, if only nicely conducted, whatever be the kind of muscle, or whatever be the animal whose live muscle is so touched, even where the muscle of a warm-blooded animal has been separated from the live animal for some time. But to magnify the effects produced by the native electric current of animals, M. Matteucci increased the intensity of the animal electric current, by *uniting* a series of separate muscles, much as we form a voltaic pile. Thus having prepared, by cutting smoothly a number of half thighs of frogs, he arranged them in regular order, so that in each point of contact of half thigh to half thigh, exactly in the same order of direction, it is, on the one hand, terminated by the interior of the muscles, and on the other, it is terminated by the exterior or surface of the thigh. Then these two extreme ends are placed in communication with distilled water, into which are now plunged the terminal platinum ribbons of a sensitive galvanometer; i. e., after being quite certain that they do not transmit any other current before the flesh is included in the circuit (as a battery) to be tested. Immediately there is obtained the evidence of a muscular electric current, and that always directed from the internal to the surface of the muscles, — the intensity of which varies according to the number of half thighs of frogs that compose the given pile; as, for instance, 3° to 4° are observed, indicated by the needle from two thighs, 6° to 8° from four, 10° to 12° from six half thighs, and so on.

### *Animal Electricity as observed in Fishes.*

The Romans employed a certain fish, centuries ago, *that gave shocks* for the cure of inveterate headaches, and for rheumatisms. The electric fish that was known to them must have been the *torpedo*, as this very remarkable fish is now found frequently in the Mediterranean Sea. M. Walsh, in 1778, made a series of

systematic experiments to ascertain the nature of these shocks, as then the Leyden vial was already known, and it was surmised

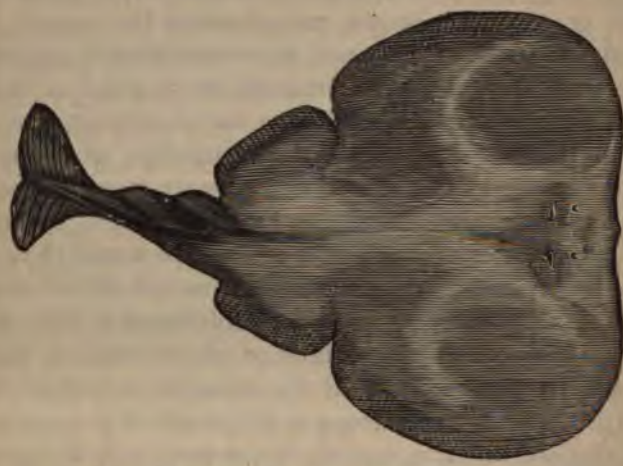


Fig. 6. The Electric Torpedo of the American Atlantic Coast.

that the "fish phenomenon" was the result of electricity. He soon ascertained that the shock was prevented by any electric *non*-conductor, as glass or wax, while the shocks were received when the fish was touched *immediately* with the finger, or even by a rod of metal. He transmitted the shock of a vigorous, recently caught fish through a circuit of twenty persons, who formed a chain by holding each other by the hand in the ordinary way, as was practised with the Leyden jar.

In the Transactions of the American Philosophical Society, held in Philadelphia, in 1786, as recorded in volume second and number thirteen, it is stated by Mr. Flagg, that if a number of persons join hands, and then one of the number touches the electric eel, they are all equally shocked, unless some one of the number is peculiarly incapable of being affected by this fish; for there was one person, he mentions, who was a most worthy lady acquaintance of his, who could handle this fish at her will; but, he says, the lady was at the time an invalid, laboring under a hectic fever.

The electric fishes, now well known to scientific men, are five

kinds or more, — the *Ray Torpedo*, the *Gymnotus Electricus*, the *Silurius Electricus*, the *Tetraodon Electricus*, and the *Trichiurius Electricus*. Gay-Lussac, Baron Humboldt, and Davy were the next to test and publish the circumstances of these *shock-discharges* of the torpedo. Humboldt proved that the discharges of the gymnotus are determined from its brain, and that they entirely cease when the four great nerves leading from the brain of the fish to its batteries are cut across, or when the brain is removed; this evidence is also obtained by an irritation of its spinal marrow, which is all the more significant, since the nerves of the *electric organs* of this fish come through the spinal marrow.

From the earliest times the ray torpedo has been the object of wonder for fishermen and sailors, as being able to give a dreadful shock either to defend itself or to kill the little fishes necessary for its food; and this property was by them often wonderfully magnified, or even imputed to various *larger* fish, which was the embellishing of their stories for centuries. This fish is flat, short, and broad, with a brown back and white belly, apparently swimming and living near the sandy bottom of the sea or harbors, much as do our flat fish, flounder, or halibut. But the body of this fish terminates with a more fleshy and short tail than the largest flounder. The space between the pectoral fins, the head and the gills, is quite filled, except in the very middle, with an extraordinary apparatus, called by physiologists, the *electric organs*. These are formed of small membranous tubes, placed perpendicular in the animal, reaching from the belly surface to the back surface, and are packed one against the other in the utmost order of regularity, as to economy of space, presenting six sides to each column or pile, much as is seen in the wax comb of the honey bee. Then each of these perpendicular tubes is minutely subdivided horizontally, by membranous diaphragms, into thin cells, which are filled with a kind of mucous secretion; and these again are traversed by a fringe of nerve filaments that come from the great eighth pair of nerves. According to Dr. Hunter, the torpedo has at each side, on an average, four hundred and seventy hexagonal tubes,

averaging one and a half inches long each, — making in all nine hundred and forty piles. Each of these, he says, has a surface of two thousand diaphragms, and between the minute spaces of these exceedingly thin and simple membranes, there is a liquid, as we have just remarked, of an albuminous nature, (nine tenths water, a trace of salt, and one tenth albumen.) These all are animated by four large bundles of nerves, which arise in the brain, and are distributed throughout all the electric apparatus by multitudinous ramifications, until they are lost in the minute substance of all the diaphragms, but terminating *exactly alike* upon the same side of each diaphragm.

But the *electric organs*, in all these fishes, are not exactly alike in arrangement, but are similar as they are in structure. Alexander von Humboldt has given a most graphic description of the gymnotus, or *American electric eel*, — also called the Surinam eel, because there found most plentifully. He relates that these fishes may kill a horse or a mule at a blow; and, consequently, a long time ago, it was found necessary to change the trail from Uritucu, through the steppes in South America, because these great electric eels had accumulated in a stream on the former route that had to be forded. He says, that year after year, a great number of horses were benumbed, while crossing the stream, by these fishes, and were thus lost by being finally drowned in this passage. We have just seen that in the flat fish torpedo, there were nine hundred and forty piles of two thousand series each; but in the *electric eel* the tubes or piles do not stand perpendicularly, but are laid horizontally from head to tail, longer and less in number. This is, therefore, the most powerful electric fish known; just as we might expect judging from the practical laws of the voltaic pile. This is admirably illustrated by a comparison with the Pulvamecher's chain, showing the relative value of numbers *consecutively* alone considered, and numbers consecutively in *series*, with a due proportion of surface, or force in each. This higher philosophic arrangement we see more nearly consummated in the electric eel. The tor-

Fig. 7. Electric Eel.

pedo fish being, as we have seen, flat and thin, the piles are necessarily perpendicular and short, reaching from its belly to its back, are very much shorter, but nearly five times more numerous consecutively than in the eel, for there are 1,880,000 diaphragms or elements, while in the Surinam eel, or gymnotus, there are only 384,000 diaphragms or elements in all. But in the eel, the animal being slim and long, the piles are laid horizontally, and each contains four thousand diaphragms, although there are only ninety-six series of tubes or piles. These lie from head to tail; hence less piles are required to accomplish the same object, for each pile has a relatively larger battery surface. The electric eel, I should have said, is some five or six feet in length, and is a more powerful fish than the torpedo, as to muscular strength.

Faraday says the shock of the gymnotus, which is, by the way, a fresh-water fish, is from its natural action in the water found to be directed from its head, which is positive, to its tail, which is negative. According to De la Rive, the shock of these animals is produced only by the will; for they can discharge *when* they choose, but not *where* they choose exclusively, for all the water for several feet about them is at once affected.

More recently, Matteucci, Savi, and Kölliker, have experimented with some of these fishes, and deduced many instructive facts. John Davy, brother to Sir Humphry Davy, succeeded in magnetizing steel needles, and even deviating the needle of the galvanometer, by repeatedly placing in contact with the two faces, i. e., top and bottom of the torpedo, the two extremities of a wire wound into a helix, or by employing the two platinum extremities of the galvanometer itself. He thus ascertained that the upper surface of this fish is *positive*, and that the lower is *negative*. The quantity of electricity liberated in any of these fishes is found to be in direct proportion to the energy of its circulation and respiration. They can effect their discharges in the air, as in the water; for, if held in the hands, the shocks are so intense and succeed so rapidly, that it is impossible for most persons to endure it. But then the fish soon

becomes weary, and it is necessary to replace it in its native element of fresh or salt water, and allow it to have a long rest, as well as nourishment, to enable it to regain its accustomed power for shocks. We must readily see the resemblance between this arrangement of nature and the artificial voltaic pile; indeed, the electric organs of all these animals constitute veritable, as visible, living voltaic piles, without metals, it is true, but possessing the arrangement of positive and negative surfaces, as if Volta himself had copied them, or they had been constructed on the voltaic plan.

Professor Colladon has still more recently observed, by a capital experiment directed to that end, a very instructive fact, which, it is true, M. Matteucci and others had observed in a less direct manner. He placed the two terminal platinum electrodes of a very delicate galvanometer, the one to the under surface of the torpedo, and the other to its upper surface, immediately after the fish had been exhausted by the effects of repeated excitations and discharges. He then wounded the fish, by cutting deep and successive gashes in its flesh. These gave no results. Next he thrust the point of his penknife into the substance of the cerebellum of the torpedo, when he instantly saw the galvanometer needle fly completely around. This experiment he repeated, by using a sharp point of ivory, in a fresh torpedo; and this was attended with exactly the same results.

The sensation produced by the electricity of this fish is felt precisely the same, therefore, as the shock produced by accumulated electricity from the prime conductor and Leyden jar of the ordinary machine; chemical decomposition or electrolysis has been effected by it; the galvanometer is readily disturbed by it, indicating a current; and a needle can be made a magnet by being placed within a helix through which this animal electricity passes; while conductors or non-conductors are affected precisely the same as by machine electricity.

If the electric organs of either of these fish be removed, electricity cannot be made manifest; so if the communication from the brain be cut off, it is not developed. If the organ is partially cut away, the remaining portion continues to discharge; or if

some of its nerves be cut, that portion of which the nerves are still entire will continue to develop electricity; if all the nerves on one side leading from the brain to the organ be cut away, that side will cease to develop it; but the opposite organ will continue to act perfectly. The *will* of the animal, or at least the integrity of the nerves connecting the brain to the electric organ, appears to be important; yet no trace of an electric current can be detected in the nerves themselves. If the nerves of an electric organ be cut, irritation of the segments of them which still adhere to the organ will excite discharges, just as the irritation of muscle-nerves so cut will cause contractions. Hence not the brain, nor cord, nor nerves, but *the electrical organ, is the generator of electricity.* Nervous power is more than electricity.

The fire-fly, glow-worm, and other insects and creatures, we know possess the faculty of generating light. The power, in each of these, resides in a particular organ strikingly analogous to that by which the fishes generate electricity, and in like manner is under the control of their nervous system; but the nervous system is not the source of the luminous emission. It is not electric light, but an animal phosphorescent light, produced by special organs in connection with, and under the control of, the nervous system.

*Animal electricity* is, then, "a power possessed by, and evolved from, certain living animals, which enables them, independently of the operation of external agents on their structures, to produce several of the phenomena exhibited by common or voltaic electricity generated in organic matter. For the evolution of this electricity there appears to be no discoverable chemical action, no friction, no alterations of temperature, no pressure, no change of form.

"The exercise of the animal will, and the integrity of the nervous system, as well as of certain peculiar organs which exist in the animals endowed with this electrical power, seem to be alone sufficient for it. All electrical fishes soon become exhausted and die, even in sea-water or their natural element, when they are long excited to give repeated and continual succession of

discharges. But the electrical power and endurance of the young fish is proportionably greater than that of the old fish, and can bear excitation and exertion without exhaustion and loss of life much longer and more uniformly." *

*The nerves of the electrical organs*, we see, are very large and numerous, and are divided into very fine twigs on the *cells* of these animal piles; while the membranes of the cells are very vascular, sending inward from the circumference, all around on each partition, small arteries, as well as nerves, which anastomose upon it, and, passing along from one to the other, unite with the vessels of the adjacent partitions; so that the sides and partitions of the electrical columns are found covered with a fine network of arteries, veins, and nerves.

Animal electricity and the polarity of the nerves are central facts in relation to pathology and therapeutics. The coarser structures are taken for inspection to illustrate the finer. The batrachian tribe and the electric fishes are, for our subject, what the cadaver is for anatomy. This is not new; it was known before this century began. So early as in 1819, Dr. John G. Munsford, of England, published an essay that set forth these outline views, but perhaps too strenuously, and being admixed with some errors, it attracted but little notice. He says, "When I see the limb of a frog thrown into contractions by the voltaic current, and when I also see the same effect produced in like manner by the animal current of nerves and muscles, as also by the current of the living torpedo, the inference, viz., that these two fluids, capable of producing the same effects, and not imitated by anything else, are the same, or nearly so, is irresistible." The leg of a frog, insulated, contracts when a spark is drawn from it by an electric machine; and contraction may also be excited by simply laying its nerve on the muscles; and when these contractions cease to be produced in this manner, they may be renewed by the application of any substances evolving electricity, or which can in any manner disturb the electrical equilibrium in the parts.

The torpedo also furnishes us with a proof *that different parts*

* J. Goldstream. Cyclopædia, vol. ii. p. 81.

*of a living animal may retain or generate opposite states of electricity, although in contact with, and surrounded by, connecting media.* Herein we have the unanswerable evidence that the motion of this nerve-force, or animal electricity, in the living animal, is not subject to the operations of the same laws which govern electricity in all other situations; for here the *control is linked with vitality*, and that within given limits during health, but is diminished or increased by disease in various ways.

It has been conceived by many philosophers that the voluntary motions of the body are produced by a subtile and mobile matter — answering in its nature and properties to the electric fluid — transmitted by the animal principle of life from the brain and other nerve-centres to the muscles. Now, if this be true, it is necessary to suppose that, as in the case of the electric eel, there is some difference in the nervous or electrical conditions of different parts of the living system, the preservation and due regulation of which must depend upon the degree of health and vital force existing in the animal. No action of the voluntary muscles, nor perhaps any irregularity in the involuntary muscles, can possibly take place without consent from the life principle in the brain and other nerve-centres. But we can easily conceive that if any cause can obtain to reduce the controlling power, without at the same time destroying the organization upon which the respective capacities of different parts of the body depend, convulsions, agitations, cramps, palsy, or pains, either general or partial, may follow.

Again, this theory suggests that, by a reduction of the vital energy, it may be unable to dispose of this subtile fluid, as it forms and accumulates in the brain and spinal marrow, or ganglia; and thus the brain may be overcharged, and, at the same time, the functions of portions, or the whole, of the other parts of the system may be languid from this effect; that, in some debilitated states of the body, it does not appear that it is so much the generation of this fluid of motion which is diminished, as its want of ready transmission to the distant parts, for the production of voluntary motion and the support of the vital and animal functions — as digestion, nutrition, inhalation, circulation secre-

tion, the formation of animal heat, and the antagonizing action of muscles.

When the balance between the formation and expenditure of the nervo-electric force is deviated or destroyed, an accumulation disproportioned to the existing capacity of the part implicated, as of the brain, or cord, or ganglia, must happen, and produce various phenomena, as tremblings or faintings, pains or palsies, cramps or convulsions, and perhaps by the regular explosions of epileptic seizures. So that although the presence of a sufficient quantity of the nervo-electric fluid is absolutely necessary for life in health and strength, and its diminution or absence may be productive of dangerous debility or death, yet it would seem that *a state of debility may also exist while the brain is charged to excess;* either the nerves, from some change in their condition or structure, having become bad conductors of the nervo-electric force, or the brain itself, from some similar change, has lost the power by which it could regulate its own state, so as to prevent an overcharge when threatened, and reserve that which it already contains, to answer the perpetual calls and wants of the system, or to be at the voluntary service of the will. We know, also, that the brain, ganglia, cord, and nerves may be so changed in their condition or structure as to be incapable, without artificial help, either for generating or conducting the nervous force. The action of lead, mercury, arsenic, and nicotine (tobacco) can induce this poisonous condition, as also sudden chill, cold or heat, or great fatigue.

It will naturally be asked, by those not accepting this theory, what becomes of the stream of electric fluid thus transmitted by the nerves from the brain, cord, and ganglia to the organs and muscles? and how can it be so speedily dissipated as that the muscular fibre shall be enabled to preserve its *negative state?* It may be answered, that a part, varying in proportion to the state of the skin, must escape through it and be lost; a greater portion when the temperature is raised by much muscular action, or by a warm atmosphere, than when it is cool; and still more when perspiration begins. The moistened surface will then favor its transit, and very much must be dissipated. But this

accounts for only a variable portion. The remainder must either be decomposed, or fixed in a manner we do not understand; although we know the law in catalysis and electrolysis, that if it takes a given quantity of electricity to build up a tissue, so will it require as much to resolve and remove it; or it may be returned instantly to the brain, or cord, or ganglia, through the blood-vessels, especially by the carbonated venous blood, as it is a good conductor. Thus a complete galvanic circle is established, and the great nerve-centres, the nerves, and the muscles are all enabled to preserve their respective states of electricity. It is possible that, from want of such a provision, we can only produce a transitory contraction in a muscle when separated from the body. Thus was early planned a gross theory of nerve and muscle action, and the cause of epilepsy, and which has been extensively accepted, but which we now cannot indorse nor accept.

*Animal Magnetism.* — It has often been affirmed that true magnetism, or *free electricity*, has to do with this unique phenomenon; but it is certainly a mistake. The so-called "*magnetic sleep*" is a stupendous fact, and that cannot be denied. However, it is only applicable to a select few of the human family, and can be performed by only a few. It is more a psychological than an electro-physiological result. Yet it is expected of us to explain mesmerism on these principles. But who can explain the phenomena of somnambulism, hysteria, or catalepsy, and a great variety of other nervous manifestations? No more can we be expected to expound animal magnetism; much less the art and mysteries, the "communications" and revelations, the "*raps*," and other wonderful attendants and suroundings of table-tipping and spiritualism.

In a certain few persons, usually those of an impressible nature, a more or less peculiar and prolonged impression made upon the senses — as by the operator looking piercingly and perseveringly into the eyes of the patient for a few minutes, at the same time either holding the hands or thumbs, or making certain slow passes in front of the patient — *will exert a special nervous quietus*, generally termed "*the mesmeric state*," or the magnetic sleep which

is evidently a hysteroid condition, partaking, in a portion of the cases, of the cataleptic character, and constituting, sometimes, a very profound sleep, which may prove fatiguing; while at other times, or in other cases, it may prove equally refreshing. The patient may be quite insensible to certain irritants during the continuance of this "*sleep*," and yet be extremely alive to the effects of others. The extraction of teeth, and other more serious surgical operations, may be performed, and actually have been in some instances, without eliciting the ordinary evidences of feeling. But, to my own mind, the most wonderful and mysterious feature of this whole phenomenon is the photographing, the telegraphing, or the *transferring* of thoughts and impressions between the operator, or the person "*in communication*," and the sleeper, (in the mesmeric state,) so that the mind of the former is known and related by the latter! — in a word, so as to know and tell, in some degree, another's thoughts.

Place has thus been given to this chapter on *comparative electro-physiology*, as observed in the fishes, not as a mere matter of curiosity, but as the more simple and powerful demonstration of *fundamental facts* relating to this department of science; and for the same reason we shall admit the testimony of other phenomena, as observed in the batrachian tribe, and in the dog, rabbit, and other animals, before we come to examine *pre-trials* in the living human organism.

## "*Animal Electricity*" *as observed in Man, but more plainly illustrated in Animals.*

Alexander von Humboldt, in order to test accurately the physiological effects of *immediate* galvanism, says he caused a blister, of the size of a crown dollar, to be placed on each of his own shoulders. They occupied the upper and outer portion of the deltoid muscles. When those two blisters were opened, he says there trickled down his back the ordinary clear serum, which dried on the skin, showing nothing but a delicate gloss from the contained lymph, and which was readily washed off with simple water. The right blister was first experimented

upon, by placing over it, in immediate contact with the raw place, a small plate of silver, that mostly covered this denuded blister; but there was neither felt nor seen any effect until the similar application of a plate of zinc over the other blister and metallic contact was made between them; when, at each contact, there was a heavy, dull sensation of burning. This sensation, he says, sensibly increased from half minute to half minute. But what was most surprising to all present was, the *appearance* of the now flowing secretion from the blisters; it was not transparent, nor was it bland, as before, but in the course of a very short time, it had become reddish, producing evidence of irritation of the skin wherever it flowed over, leaving there reddish stripes. No angry wound could produce such acrid liquid and quick-made excoriations. The gentleman who aided in these trials repeated the effects by reversing the arrangement of the silver to the left shoulder. In four minutes, violent inflammation set in, with increased local redness, together with the excoriations of purple and red stripes, produced down the back by the moisture that flowed from under the metal plates that were thus on the raw surfaces. When the experiment was ended, says Humboldt, notwithstanding all the care taken to gently wash away the flowing moisture as well as could be, still did his back appear like a whipped criminal. This very remarkable experiment, for testing the physiological action of that method of using galvanism, was given by Baron Humboldt, the Nestor of natural science, early in the year 1790, and even before the discovery of the voltaic pile, but after the discovery of the electro-muscular contractions by Galvani, through the twitchings of dead frogs from metallic contact.

Another arrangement of the prepared frog thighs, made by Marianini, proves the same facts, and renders these fundamental results familiar; and for that reason they are repeatedly shown in this work. The frog is to be prepared as before in Galvani's original method, but arranged now so that one leg shall be placed in each of the two glasses of water. If, then, the poles of a moderate current are quickly plunged into the water of the respective cups, the legs, if from a recently-killed frog, will

spring out of the cup; but if now we forcibly retain them in the cups, and then frequently repeat the closure and opening of the circuit, we shall for a while see twitchings in both legs, and that as well on opening as at closing the circuit. Then, by continuing to operate thus for a time, the excitability diminishes or exhausts, until we notice that only one of the limbs contract, and that when the current is *closed;* and this is the limb with the negative pole, and where, of course, the current runs down it. But if the poles are plunged into the water and retained there for a little time, then, on removing them, or one of them, the twitching is seen to take place in the opposite limb, i. e., in that one that is traversed by the current running up it. If the trial is reversed, by exchanging the poles in the cups, and thus causing the current to run up the limb where it had before run down, and *vice versa*, the result will follow in accordance with the same law, viz., the closing contraction will now be in the limb where before was the opening.

Further: if the thighs of two frogs are now prepared, as before described, and the four large nerves are placed in the same glass of water with them, while the flesh of the two legs of the one frog is transfixed by the positive electrode, and the flesh of the two legs of the other frog is similarly arranged with the negative pole then the frog that is at the negative, and traversed with the direct or down-running current, is seen to tremble at the closure of the current, whilst at the opening of the same the trembling is seen in the other frog legs, where is the positive pole, and the current is traversing indirectly, or up-running. This trembling in the one experiment, and the twitching in the other experiment, arise, as we see, under opposite directions of the current.

Marianini further observed, that when electricity acts immediately over and upon a muscle, contraction takes place *only* at the instant when the current is closed, whatever be the direction of the stream. He therefore termed this mode of action the *idiopathic*, to distinguish it from the action produced by applying the electrodes over the nerve trunk of that muscle which he termed *symptomatic*. By thus operating on a live frog, whose

posterior limbs remained attached to the living animal *only* by the two carefully exposed nerves, (sometimes termed lumbar, sciatic, ischiatic, or crural nerves,) and placing the hind legs in contact with one pole of the battery, while one or both of the fore legs are in contact with the other pole, as by placing them respectively in little shallow vessels of water, — if now the stream traverses the hind legs *directly*, or down-running, the frog will agitate those posterior limbs *at the moment when the current is closed*. But then, at the moment when the current is *opened*, the frog utters a prolonged cry with the full force of its lungs, as from pain, and at the same time raises itself with rigid contortions on its fore legs or arms, without the least agitation of the posterior legs. Then, after a considerable rest, if the current is reversed so as to enter the hind legs by the feet, and hence in an inverse direction, it is now, when the current of electricity is *closed*, that the frog utters its cry, accompanied with contortions, &c., and it repeats the cry if the circuit is left a little longer closed; but when opened, the posterior extremities are agitated again, and the animal ceases to cry or show contortions.

By this we see that the contractions take place only at the closing or making of the circuit, and not at its opening, if the current or stream is direct, or down-running; and only appearing at its opening or discontinuance, and not at its closure, if the current is the inverse or up-running, i. e., towards the spinal marrow and brain.

We do not usually observe any sensible contraction of muscles when under the *steady* running of a *feeble* current of galvanism. But this, as say Remak, De la Rive, and others, does not prove that there is not a certain effect being produced on the nerves by the steady and gentle inworking of this current. Indeed, here, according to my experience, is one of the most marvellous and valuable effects of all the medical uses of electricity. Even as long ago as in Volta's day, it was known that the prolonged action of a steady current in the same direction, — say for an hour or so, — on the nerves of a mutilated frog rendered them so that contractions were no longer produced,

either at the making or breaking of that current. But the instant it was exposed even to the same current *reversed* in direction, the frog showed very violent contractions and agitations, even stronger than at first.

Therefore, the continuous action of any moderate galvanic current, we may then safely conclude, *does not* produce any sort of disorganization of the nerve, as has been so frequently taught, but that it rather *modifies* it, to a certain degree, so that it obtains *a new susceptibility*. If the nerve is sick or diminished in its physiological irritability and power, this current can increase and restore that; if the nerve is already alive and in health, it can thus be exalted above the normal. When, by a protracted duration of the same even directed stream, the nerve gets accustomed to this new state, it may remain so for a considerably shorter or longer time, even after the cause that has produced this changed state is removed. For we notice that, if we suspend the action of such current for a few moments, and then apply it again in the same direction, we find it produces no sort of effect, because it finds the nerve in the same condition still which that current tended to produce on it. It is no longer the same, however, if now the direction of the current is changed; for the more the nerve has become accustomed to the first current direction, within certain bounds, all the less will it tolerate the action of the second, or reversed. But what this exact modification is, we can only infer. It clearly proves, that the modification produced by each direct and inverse current, and by each closing and opening current, is, in fact and effect, very different.

Actual trials show that the artificial section that is obtained by cutting a living muscle transversely with a very sharp instrument gives exactly the same result, as to animal electric currents, as the transverse test of the muscle while intact. In fact, almost no current is obtained upon placing lengthwise, between the poles of the galvanometer or the galvanoscope, simply the *middle* portion of red muscular flesh, cut clean and transversely from all its tendonous attachments at the two ends, and stripped of its investing fascia. The same negative results are

obtained likewise if the clean platinum tips of the galvanometer touch only the tendonous extremities of an entire muscle. But, on the other hand, a very decided effect is obtained by placing in contact on the one side an artificial transverse section, and on the other the longitudinal section of the muscle, — the course of the current being found always directed in the muscle *from* the transverse *to* the longitudinal section. De la Rive, therefore, sums up the *law* of the muscle current by stating that each point of the natural or artificial lengthwise section of a muscle is positive, in respect to the points of the transverse section, whether natural or artificial, and that the points that are the nearest to the centre, in all respects, are negative with respect to all those which are more distant.

From the above and other facts, we deduce that the phenomena of animal electric currents can only take place in a living organic tissue, and which, when once it has disappeared by *rigor mortis*, cannot again be produced, even when that rigidity has ceased. This is, indeed, a further proof that muscular electro-motive force, is very dependent upon the arrangement the *vital influence* imparts to the organic molecules in the ultimate structure of the muscle fibrils, — an arrangement that in various degrees endures for some little time after death, as also does irritability, but which disappears forever, as soon as decomposition sets in, and the particles are no longer subject to the laws and force of vitality, that so absolutely rule in and over organic matter. M. Matteucci supposes this to decrease at death, and the more rapidly in proportion as the animal occupies a higher rank in the scale of beings. M. Dubois-Reymond attributes this difference rather to the fact that all warm-blooded animals, mammiferous, and birds lose their muscular irritability after death much more rapidly than fishes and reptiles, and other cold-blooded animals. He lays down, therefore, as a *rule*, that the diminution in the animal electric current after death is proportional to the degree of natural excitability of the muscles; and that the electro-motive force, as well as excitability, have for their termination the *rigor mortis*. M. Bruke has shown, that *rigor mortis* is the result of the coagulation of the

fibrine contained in the bundles of muscle-fibres *outside* the blood-vessels, and that this state ceases when microscopic decomposition thaws it away.

But of all the influences that are exercised over the native or natural muscular current is the contraction of the muscle itself. This is brought about by *nerve irritation;* as by the imparting to a motor nerve, and that, perhaps, first through a sentient nerve by physical, mechanical, or chemical means, a particular state that is usually manifested by a contraction. To effect this, the most reliable and efficacious of all means is the transmission of an artificial current of electricity through the nerve; and this is modified again most astonishingly by the *form* of the current, and by the *mode* of applying it, as well as by the *condition* not only of the nerve and muscle, but also of the central organs. Consequently, the greatest possible precaution is requisite to the correct employment of this agent *as a remedy*, by influencing, disturbing, and even determining the native muscle and nerve currents that are disordered. As an illustration, it may be stated, that the actual passage of every electric current of induction, through a nerve or muscle, is found to produce a degree of minute tetanic contraction, which may not always be visible to the naked eye, nevertheless is attended at first with a sudden change in the direction of the native current; then there is an oscillation, as manifested by the needle of the galvanometer, which then appears to be unable to come to a rest in any position of equilibrium so long as this artificial tetanic state endures.

This result, which was first pointed out by M. Matteucci, has been designated by him as the *induced contraction.* M. Dubois-Reymond appears to have demonstrated that this induced contraction, which he terms *secondary*, is only one form of manifested *variation of intensity* that the native muscular current undergoes, and that this deviation is a weaker one. To illustrate the existence of the muscular current in healthy living men, Reymond plunges all the fingers of both hands respectively into two vessels which are filled with salt water, but in-

sulated, and communicating only by the conductors of the galvanometer, and prepared with every precaution, so as to be deprived of all electro-motive force whatever. Then, when the needle has become tranquil, he contracts all the muscles of one arm as powerfully as possible, at the same time taking care to avoid the least movement of the other arm and fingers. At the moment of contraction the galvanometer shows an impulse, the intensity of which depends upon the strength of the subject and the adroitness of the operation; but the invariable direction of the current travelling in the contracted arm is *from the hand towards the shoulder* — the reverse of what it is when at rest.

This reverse direction of the animal electric current he thinks can only be attributed to the diminution or exhaustion, or negative variation, as it is called, that is suffered by the native muscle electric current, and produced simply by the contraction of the arm; whence it is inferred that the natural current in the arm that was kept at rest preponderates; for before the trial, their respective animal currents balanced each other, because of their similarity. The natural animal electric current, however, of the human arms, during life and health, travels, in each of them, in the direction *from the shoulder to the hand;* i. e., *from the nerve centres to the periphery and extremities.*

Electricity, therefore, acts upon the animal body, both in health and disease, in a manner that all scientific observers acknowledge to be peculiar to itself, and producing results otherwise unattainable. Dr. Galvani, as we know, was the first to produce muscular contractions by the aid of galvanic electricity. His first trials in this line, let me repeat, were upon the frog. He cut the frog across in the middle, and then after quickly opening its body, the points of the scissors were passed beneath the two visible lumbar nerves, which are plainly seen lying superficially upon the psoas muscles, as the frog lies opened and upon its back, like two white threads. It is well, in preparing the frog for this experiment, to remove two or three of the lower vertebræ, and thus the lumbar nerves are left alone as the only connection between the thighs of the hind legs and the upper vertebræ of the body. If, now, this portion of the frog is quickly

and adroitly placed, say suspended to an insulated electrode of a feeble battery by the cut tips of those large nerves, and then the leg muscles are touched by the other insulated electrode, — not insulated from the frog, but from every thing else, — so that a gentle current passes from the nerve to the muscle group of the leg so touched, or to both legs if both are so touched simultaneously, then the limb or limbs are seen to contract with an

Fig. 8.

extremely sudden and strong twitch. If this trial is made by placing the legs of the frog each in a separate glass of water, and then plunging the electrodes into the water of each, that instant the frog's legs undergo so sudden and violent a contraction, that they are often thrown entirely out of the glasses. It is not necessary to include the whole nerve and muscle in the current to produce this effect; for it is found that a very short portion is sufficient, and that the nearer the upper portion, the greater the effect from the same current.

It is said that in 1818, Dr. Ure made some capital trials with electricity on the body of a man who had been hanged, immediately after the execution. He expeditiously submitted the fresh body to the action of a galvanic current from two hundred and seventy series of copper and zinc pairs of sixteen square inches of surface each. To reach directly the larger nerve trunks of the but recently dead body, he made incisions into the flesh, so as to place one electrode in actual contact with the spinal marrow, while the other was in immediate contact with the great sciatic nerve. By now closing the circuit, all the limbs of the body were agitated by convulsive movements. Then, again

taking the electrode that was on the sciatic nerve, and placing it farther down, at the heel or ankle, the knee having been previously bent, the leg was extended with such violence that it very nearly overthrew one of the assistants, who endeavored in vain to prevent the extension. He also produced contractions of the diaphragm, which caused an artificial respiration.

Thus, in the early part of this century, the bodies of a very great number of criminals were subjected to a wide variety of experiments, by Ritter, Rossi, Wassali, Julio, Matteucci, and Wilson Philip. The former, indeed, thought he had discovered that electricity of the positive pole increases vitality, whilst that of the negative pole diminishes the vital forces; and that the former swells the muscles and fortifies the pulse, while the latter relaxes the muscles and reduces the pulse. He also fancied he found a difference in the action upon the organs of sense. Dr. Philip, by dividing the eighth pair of nerves in living animals, believed that he might substitute the artificial electric current of galvanism for the natural nervous force, as in digestion, secretion, &c.; while others advanced the idea plainly that nervous force is simply and only an action analogous to that of voltaic electricity, independent of vital force, — in fact, *as constituting vitality itself*.

But all these were evidently hasty conclusions from mere semblances, or from false premises, to which the author only alludes because still quoted as if true. We will therefore leave aside, as much as possible, all speculations and *curious* researches whose results are now contested, to occupy ourselves in a more precise and scientific manner, consulting only those physicians and philosophers *who have been especially engaged with this particular branch of research*. Most of all do we wish to learn the real actions of the different electric currents, and the various modes of employing those currents upon the different parts of the living human organism, and to confine ourselves mainly to stating, as concisely as can be to be clear, the positive facts that the now multiplied experiences by competent men in actual clinical practice, have thus placed beyond all kind of doubt.

Inasmuch, therefore, as physiological action may be consid-

ered as a *source* of electricity, as it certainly is, as well as *influenced by* electricity, we may be able all the better to rightly estimate that share of influence in the phenomena that are brought about by the applications of electric currents or shocks, when we also comprehend the work of the natural electric currents which the human organism possesses, and which are inseparably connected with its healthy functions, as well as its abnormal states, and actions.

It has been clearly demonstrated by Dubois-Reymond, aided by his exquisite Galvanometer-multiplier, that there exist in the *nerves*, as in the muscles, of man, perfectly determinate currents of animal electricity. This is as true of all the nerves as of the living muscles, whatever their respective functions, as well in the nerves of sensation as in the nerves of motion, in the anterior as in the posterior root, and in the mixed nervous centres as in those that are simple. The nerves of man and of animals in this respect present the same phenomena, and are subject to the same laws, as the currents in living muscles. The latter are supposed to be only the effect of the electric polarity of the ultimate nervous partitions, and of the arrangements which they assume under the all-controlling influence of the undefinable *vital force*.

Fig. 9.

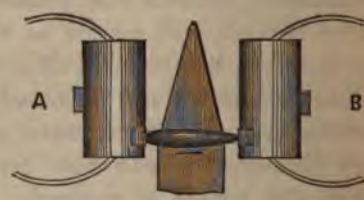



Fig. 10.

For these nice experiments, the ends of the two silver wire conductors of the galvanometer, that lead into the cups of fluid, should be provided with perfectly clean and equal platinum plates, through which the animal nerve-current, or muscle-current, can pass to the coil of the instrument, to affect the needle; and these bits of platinum must be homogeneous. To keep

them so, when the apparatus is not in use, the plates should be always kept in the cups and liquid, and then connected also by a wire, as well as the liquid, so as to form a perfect circuit, and prevent polarity. Two clean glass vessels of about three inches in diameter, containing a saturated solution of common salt, receive the two platinum tips. Now, the little space between the two cups, that is to be bridged over by the muscle or nerve to be tested, must be prepared for the more delicate experiments.

For this, Dubois-Reymond employed cushions of soft blotting paper, made of many layers folded, and saturated with the solution of the cups, which are to be alike. These are adjusted on the rim and side of each of the glass cups, so that one end dips into the fluid, as shown in Fig. 9. To complete the circuit, when experimenting, there is seen to be another cushion of this wet blotting paper to close or perfect the circuit, in the place of the wire, up to the moment of test. Then, to bring the animal part delicately into the circuit of the galvanometer, the third or middle cushion is to be removed, and the effect observed.

Still, the animal part must not be laid directly on these cushions, lest there be a corroding action. To avoid this, a thin layer of mica, albumen, or bladder may be placed upon the cushions as guards. A strip of glass may support the muscle between the cups. Thus these immensely interesting facts may be examined as in Fig. 10.

In order to find the muscle-currents, Dubois-Reymond examined the same muscle by various methods, by placing it in different ways on the cushions. In the position as seen in Fig. 11, the muscle causes no, or but very slight, deflection; but if one end of it be bent up, and the vessels pushed closer together, so that the red flesh of the muscle touches one cushion, while its tendinous end touches the other, there is a very marked deflection of the needle. Fig. 11 shows a muscle lying upon the guards and cushions.

Fig. 11.

We thus approach another epoch in the history of electro-physiology and electro-therapeutics: I refer to the researches of M. Dubois-Reymond. It appears to have been the main object of this great man to test and put to rest the truth as to the nature of the powers active in the nerves and muscles of living men. To demonstrate, — the identity, or *degree of identity*, there is between the electro-motive force, artificially produced, and the functional force of the living human organism, and to ascertain the workings of electric currents through the nerves and muscles as nature's method or means to put the original powers of these textures into action, — we shall have to recur frequently to the general theory of *nerve and muscle excitement* developed in his hands, from the very careful and conscientious trials he so perseveringly instituted.

The *electro-tonic state*, or "electrotonus," so nicely examined by him, arrests our first attention. After Dubois-Reymond had ascertained that not merely the muscles, but also the nerves, of a recently amputated limb show a *sui generis* electrical current, called the *quiet nerve current*, and always flowing from the longitudinal to the transverse cut of muscles, he observed, —

1. That this native current *increases in strength* as long as a constant current is made to flow along on the edge or side part of the nerve region that is being tested, provided the artificial current, that is so applied, runs in the same direction with the natural nerve and muscle current.

2. That the native nerve and muscle current *decreases* when the artificial constant current is made to run in the *reversed* direction.

3. That the native nerve and muscle current *ceases* to flow, while and as long as the nerve is disturbed, or is being excited, as by means of interrupted induction currents; or by mechanical or chemical irritations that are strong enough to produce a motion or sensation. The last-mentioned oscillating or staggering of the nerve current is by Dubois-Reymond termed the *negative state*, while the first-mentioned changes he terms the *electro-tonic state* of the nerves.

This view, deduced from all these facts, is also verified by

another fact — *that the electro-tonic condition of the nerves is developed under all those circumstances by which the action of the nerves appear visibly increased;* and that this ends in contractions, that is, with the *mechanically expressed capability of the nerves and muscles for action.* This, however, by no means should lead us to mistake this electrotonus as one and the same thing, exactly as that natural circumstance or cause that produces sensation and contraction. This circumstance, or cause, is temporarily called forth by the artificial application of the current, at the moment of interruption, or by alternation, or by an increase or decrease in the *density* of the current, — which also causes the positive or negative variation in the native electric current in the nerve; but electrotonus continues of the same strength as long as the circuit remains closed, even when the artificial current is weak.

Dubois-Reymond, in order to point out the true signification of the electrotonus, reminds us of the proposition which Ritter and Erman had already advanced on the theory of convulsions, and thus discovered a *law*, partly from the after observations of Nobili, and partly from those of MM. Becquerel and Matteucci, namely, that the circumstance, or cause, producing motion, and arising at the moment the circuit is closed, is to be found in the electro-molecular change of the nerve, which is in effect *an altered condition of the nerve;* that, moreover, the activity of the applied current consists in placing the nerve in this condition and *maintaining* it so as long as the electric current is directed there; that finally, the opening convulsion is nothing else than the *replacing* of the nerve from the changed condition, back again into its natural state, as soon as the restraint of the irritating current has been removed. From this, too, arose the aphorism of Ritter, "*It is the organism, and no other, which produces on itself the opening shock.*"

When a current acts upon a nerve, the latter then becomes circumstanced the same as any other wet conductor. Electrolysis is produced, commencing with pile-formed or pyramidal polarization. The change from a natural into a di-polar adjustment of the electro-motory molecules occasions that disturbance

of equilibrium, which shows itself according to the direction of the current in a closing convulsion, or in a closing pain. It is the return from the bi-polar to the natural adjustment again, by which, to speak in Ritter's words, the organism gives to itself the opening shock.

To these observations Dubois-Reymond advances a justification for the term *electrotonus*, as applied by him to nerves and muscles. He, in the first place, reminds us of the already stated similarity that appears between the source or cause of the nerve excitement by means of the current, and that of the induction of a current-leading conductor, or magnet, to a neighboring and parallel conductor. Just as that element which produces sensation and motion does not always arise to the same degree during the continuance of the current, so the induction takes place only in consequence of positive and negative alterations in the electro-dynamic or magnetic resultants, acting on the conducting element. Now, as Faraday has designated that condition of the conductor, into which it has been brought by induction causes, *as the electro-tonic condition*, — the actual existence of which he in latter researches has been able to demonstrate by ocular means, — so the pile-form polarization of the nerve is entitled to the designation which Faraday has thus prepared for it.

When a current is produced by closing a circuit that embraces a living nerve, it is accompanied by an excitement and disturbance of the element of motion and sensation. The nerve, indeed, becomes polarized, pile-formed, or in pyramidal order, which is the electro-tonic condition. When both poles of the battery are removed, and the current is thus opened, the electro-tonic condition of the nerve-conductor disappears, and the molecules return from the induced di-polar to the natural polar state of a healthy nerve; whereby we see manifested the same contrast between the closing and the opening convulsion as between the closing and opening current, viz., the closing convulsion shows by the down-running currents the same peculiarities which the opening convulsion presents by the up-running current, and *vice versa*.

*Electro-motory Properties of Nerves.* — The instrument by which the presence of an electric current in a nerve is ascertained, is termed a *galvanometer;* and, for testing nerves, it must be one of exquisite delicacy. This, as is now well known, consists of a long coil of *fine* wire, within which an *astatic* magnet needle is suspended. When an electric current, though ever so slight, traverses this coil of wire, a variation of the needle to the right or left is instantly observed. The *degrees* of variation depend upon the intensity, while the *direction* of the needle-variation depends upon the *direction* of the electric current thus searched for and tested.

*Galvanometer.*

For all the nicer tests in the study of electro-physiological phenomena we are depending upon the Galvanometer-multiplier and the Galvanoscopic frog. The former is delicately constructed by our electrical and philosophical instrument makers. But the latter requires precautions that are to be remembered in preparing it afresh from time to time, as it must be done. First, the frog must be fresh caught and vigorous. The leg must be of very recent amputation. Care must be taken to preserve and separate the ischiatic nerve as long, and with as little handling, as possible. The leg must then be perfectly insulated. We must close the circuit of the experiment with the nerve alone, carefully avoiding any touch of the muscles, so as to not include any of its influence. The pendulous nerve, fresh and moist, must alone be touched in two places by the two points that are suspected to be the poles of the electromotor element that we desire to study. If all is thus correctly done, the leg is then seen to contract instantly, if any such force is found. Also, with a very great degree of certainty, we may determine the *direction* of the current. For this end we choose a frog's leg that is become enfeebled a lit-

Fig. 12. Galvanoscopic Frog.

tle, and thus some less excitable. If, now, the current is brought to bear upon its nerve, in a direction *up-running*, i. e., from the leg towards the cut end of the nerve, we see the contraction at the *instant* the current is closed. On opening the circuit it is motionless. But if the current is directed so as to course the nerve of the prepared leg in a reversed or *down-running* direction, then the reverse obtains — i. e., motionless on closure, but contraction on opening.

Fig. 13. Galvanometer.

The employment of the Galvanometer instrument for accuracy and delicate purposes also requires the utmost precaution. It is necessary, first of all, to *avoid* any chemical action, even of the animal liquids, upon the platinum plates, which serve to bring into the circuit the various organs or tissues whose electric

state we are studying. To this end we must use pure platinum plates of equal size, cleansed with exact care. Then we must even allow them to be plunged into pure water for some time, to prevent the simple immersion from giving rise to some current, as it is so liable to do. When thus quite sure there is no action, we then touch at the same time, with these two poles insulated, the animal parts to be tested. But the mere fact of the circulation of a current polarizes the p[illegible]nders them afterwards capable of producing, witho[illegible]ause, a delicate secondary current. For this reason[illegible] never attempt to test twice consecutively, wit[illegible]care to depolarize the plates thoroughly, by plac[illegible]are distilled water for a time, while they remain in meta[illegible]ommunication.

In the researches of Dubois-Reymond we have a demonstration of the extent to which an organic structure can be subjected to physical examination. He has shown that every piece of fresh excitable muscle is the natural source of electric currents — as can be proved by placing the two ends of the wire of a sensitive galvanometer in contact with it; but it is found that the *condition* and the *position* of the muscle greatly modify the result obtained. This is equally true of the nerves.

It has been assumed that in the interior of muscles and nerves there are an infinite number of centres of electro-motive action, each of which may be represented as in Fig. 14. In each of these electro-motive molecules there is, probably, a positive equatorial zone, and two negative polar zones, as here shown. Dubois-Reymond calls these the *peri-polar molecules*. The axes of all these molecules must be parallel with the axes of the fasciculi. The vertical boundary, as from *a* to *e*, and *b* to *f*, represents the lengthwise

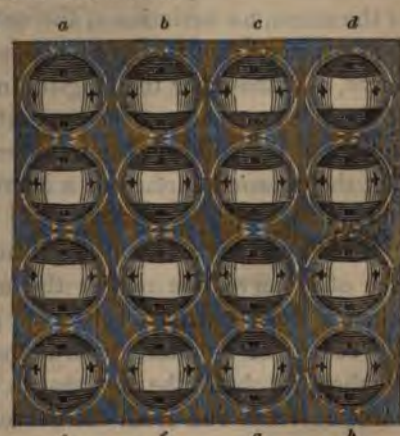


Fig. 14.

section of the muscle; the horizontal boundary represents the transverse section; the shaded background is the wet conductor. This explains, in an electrical point of view, the voltaic condition of a healthy muscle while refreshed, and in a state of rest.

Fig. 15.

Fig. 15 represents more clearly this minute animal electric state of the muscle, but shows the peri-polar molecules as groups of two *di-polar* molecules touching one another with their positive poles. Dubois-Reymond says, "It remains only to be stated that any mechanical agent, for instance the keenest razor, never can separate the two di-polar molecules, which form together a peri-polar group; but it always passes between two such groups, in consequence of which any artificial transverse section will always show negative to the neutral longitudinal section."

If the nerve be placed so that the wires touch two points of its *surface* at an equal distance from the middle, as to the length of the nerve, no deviation of the needle takes place. If the wires are so placed that the one touches the transverse section of the nerve, and the other the longitudinal surface, a strong variation of the needle ensues — the current going from the point on the surface to the point on the transverse section. It is thus proved, that the external surface of a nerve is positive (+) towards the transverse, which is negative (—) in its electric relations.

If both wires of a sensitive galvanometer be placed on the surface of a nerve, one nearer the middle of its length than the other, a weak current is observed going from the point nearest the centre, or equator, towards the point at a distance from it. So, then, we obtain the *law*, that in living healthy nerves, electric nerve-currents run from the nerve-centre outward in all directions; that is, a point at or near the centre is + towards any point — at a greater distance from the nerve-centre; and this is termed *electro-motive power*.

This electro-motive power thus acts according to a definite law, which was termed by Matteucci "the law of antagonism of the longitudinal and transverse sections," the former being negative, and the latter positive. Thus we learn that white nervous matter in the living animal, or in a very fresh state, possesses electro-motive power, always acting in a healthy nerve by a given law, so that in the longitudinal section we find every point near the equator is positive towards any point at a distance outward from it; and in the transverse section an analogous relation probably exists, although it has not as yet been absolutely proved by demonstration.

Fig. 16 may serve to illustrate the molecular arrangement which the interior of the nerve is believed to possess while in health and *at rest*. Fig. 17 represents it as conditioned when the nerve is completely polarized — as when telegraphing the senses, or the orders of the will for muscular action, as also when under the influence of an artificial, but controlling, electric current. It is impossible not to admit that their positive faces are electro-positive, and their negative faces are electro-negative.

Fig. 16.

Fig. 17.

M. Dubois-Reymond, aided by the microscope, and his prodigious researches, has given us a theory to explain these demonstrations of electro-motive force, viz.: —

Every nerve *molecule* is polarized, and acts according to the same law as the whole nerve. In fact, a nerve consists of a number of di-polar molecules, one half presenting positive, the other half negative, electric properties. These di-polar molecules are arranged in couplets, and in such a way that the positive poles are turned towards each other, while their negative poles are turned towards the extremities of the nerve. Now, if each couplet of molecules produces currents going from the central positive poles to the negative poles, the nerve must always be in the condition of a closed voltaic current. When the wires of the

galvanometer are applied for the test, but a part of the nerve-current is abducted and made manifest; because, if the whole length of the piece of nerve is enclosed, the two opposite currents, running each way from the middle or equator, will counterbalance each other, and give no deflection of the needle; while if but a part of the nerve is embraced, so as to include more of one side of the equator than of the other; or, better still, if from the equator to the one end be only embraced between the wires, then we get the needle deflection produced by this part of the nerve-current.

The above facts and theory apply to the healthy nerve while at rest; and, taken together with other facts well known, we obtain the law that the electric nerve-current, also called animal electricity, always flows *from* the brain and the spinal marrow — the great centres — outwards towards all the periphery in healthy nerves, *while not over-fatigued.* In isolated muscles the same law is found to hold good, namely, the same as that of the piece of nerve; the point nearest the central axis is + towards the one nearer the periphery. Taken as a whole, the currents of the body are from within outwards, from the insertion of the limbs outwards towards their extremities. In fact, the muscle-currents are probably the continuation of the electric nerve-currents emanating from the great nerve-centres.

Fig. 18.

There is a nervous current, as well as a muscle-current; but how does the former act, or how is it affected while the nerve is conveying to the muscle, or to the central organs, as the case may be, those material changes which become perceptible as sensation and motion? To explain this, let a nerve be placed with one of its ends upon the cushions, and with the other on the platinum ends, as shown in Fig. 18. The nerve-current of the portion of nerve that is between the cushions of the galvanometer will produce a constant deflection of the needle in the galvanometer. If, now, the platinum plates be brought into metallic connection with the positive and negative poles of a little battery,

so that a constant current passes through that part of the nerve, then an increase or decrease of the nervous current, according to the direction of the applied current, as indicated by the galvanometer, will occur. If the current of the battery be in the same direction as the nervous current, there will be an increase in the intensity of the nervous current; but if in the opposite direction, there will be a decrease in the nervous current. The altered condition of the nerve thus produced is termed the electrotonic state of the nerve. If that be increased, it is termed the positive phase; if diminished, the negative.

*Electrotonus.* — When a constant voltaic current is made to traverse a nerve, or a portion of a nerve, an electrical change is produced, to which the term *electrotonus* is applied. Suppose that a piece of fresh-cut nerve is properly placed for the galvanometer test, and there is seen a constant deflection of the needle, produced by the native electric nerve-current; if, now, a constant current be passed through this piece of nerve, *in the same direction* as that of the natural nerve-current, then an *increase* of the deflection of the needle is observed. This is termed the positive phase of the electrotonus. But if the voltaic constant current be applied in a direction *opposite* to that of the nerve-current, then the needle of the galvanometer is *decreased*. This is termed the negative phase of electrotonus. If a nerve is placed with its middle or equatorial point exactly between the insulations, so that no deflection of the needle is produced, and if the current be now applied to the nerve, in either direction, a deflection of the needle will take place; but its direction will be in accordance with that of the applied current.

Thus we learn that when any portion of the length of a nerve is traversed by an electric current, we get, besides the original nerve-current, the evidence of a new electro-motive action, which has the same direction as the applied current. So that this new current-force is *added* to the native nerve-current, *if the direction is the same*, — that is, it is increased; but if the direction is opposite, it is *subtracted* from it; or, in other words, it is diminished.

If, then, we suppose the electro-motive molecules, in the natural resting state of the nerve, to be arranged, as seen in figure 16, with their similar poles turned to each other, yet some change in their arrangement must be brought about during, and in consequence of, the electrotonic state, or as constituting this state. The effect of the artificial current, when applied to a nerve, is found also to produce different results, which depend upon various circumstances, such as the given part of a nerve included in the circuit of the primary current; as also of the galvanometer; the length of nerve between the points of its application; as also on the intensity and variation, or waving strength of the constant stream, &c., employed to produce the polarization of the nerve and depending muscle, which is supposed to be an electrolytic process.

Under the influence of the applied voltaic or galvanic constant current, the molecules of the nerve arrange themselves so that their negative poles are all turned to the point at which the current enters the nerve, the positive sides or poles of the molecules towards the point at which the current leaves the nerve, which would be under the negative electrode. Instead of the natural arrangement of the molecules, as in Fig. 16, where the similar poles are turned towards each other, we get the condition of Volta's pile, as shown in Fig. 17, when the opposite poles are turned to each other in a regular series. The former illustrates a nerve that is healthy and at rest; while the latter illustrates a nerve that is active. To obtain the position of the molecules, as shown in Fig. 17, there must be required, in some of them at least, a rotation of 180°. This pile-like arrangement must occur not only between the electrodes, but also external to, or beyond them; for the nerve is electromotory, in the sense of the exciting current, throughout its whole length. Here the question occurs, If all the molecules assume the arrangement of a perfect voltaic pile, how is the original nerve-current reproduced, as seen in Fig. 16? Dubois-Reymond teaches that the pile-like polarization is more or less imperfect; that is, some of the molecules do not fully rotate under the influence of the applied current, but remain more or less in their original position, and this all the more the greater

the distance from the polarizing electrodes; for when the exciting current is withdrawn, the molecules again assume, in more or less degree, their natural position.

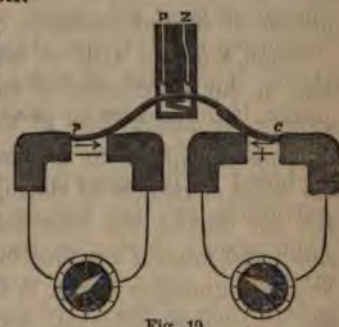


Fig. 19.

We might readily conjecture, from the foregoing experiments, that when the nervous current is simultaneously tested by galvanometers at the two ends of a nerve, while the excited portion, as by a battery, is situated between, we might see at one of the ends an increased intensity of the original nerve-current, and at the other a decrease; but this is not so, as Fig. 19 illustrates. To show this, two galvanometers and two pairs of conducting vessels, with their cushions, are of course necessary. Thus prepared, as shown, it results that the nervous current in each galvanometer is increased when the battery-current coincides with the native nerve-current, and is decreased when the two current-directions are opposed to each other. From all this is deduced the following: —

*When any portion of the length of a nerve is traversed by an electric current, besides the usual electro-motive action of the nerve, a new electro-motive action takes place in every part of that nerve, which has the same direction as the exciting current itself.*

Fig. 20.

It has been demonstrated that the electrotonic state of a primary excited nerve produces a secondary electrotonic state in a contiguous nerve. This is not only true in fact, but can be proved by experiment. Fig. 20, given by Dubois-Reymond, explains the mode of performing it. In this figure the nerve on the cushions, in which the secondary electrotonic state is to be observed through the galvanometer which is attached to the

cushions, is supposed to undergo the positive phase of this state, induced by the action of the negative phase in the primary excited nerve; — so that a given condition of a certain nerve can induce an altered condition in the neighboring nerves.

When a nerve, with an attached muscle, is irritated, we obtain, in the contraction of the latter, a proof of the physiological activity, or excitability, of the former. But when a continuous current is applied to the nerve of a muscle in an even stream, the latter contracts on closing, and again on opening, the circuit, but not during the time the current is running, and while the nerve and muscle are thus being held in a state of electrotonus. Now, the question arises, Is this state or *condition* of electrotonus the electro-physiological *active state* of a living nerve, or is the instantaneous inducing, and again resolving, of the electrotonus state, the true condition of the nerve-action, as during action? This is illustrated by the fact, that when a continuous voltaic current is applied to the nerve of a muscle, as we have just shown, the muscle contracts only at the instant the current is applied, and again as it is being removed, but not during the interval while the nerve is held in a state of electrotonus. But if, instead of the primary continuous current, a series of interrupted currents be applied in very quick and rapid succession, the contractions follow each other so quickly that the muscle has no time to regain its state of relaxation; therefore it is held in a state of continued contraction — an induced tetanus. If the effect of such an interrupted current on the nerve be examined by the galvanometer, the result will be found to be different from that of the continuous current. With the continued voltaic or galvanic current, the positive phase of electrotonus is denoted by an *increased* needle deflection, the negative phase by *diminished* deflection of the needle, which are termed positive and negative variations. The positive variation from the natural standard — i. e., the nerve-current increase — is greater than the negative variation. So likewise with an interrupted current, positive and negative variations of the needle of the galvanometer occur; but here the positive phase, or variation from the par of natural, appears decidedly less than the negative.

Such results actually obtained lead to the belief that in tetanizing a nerve, the original nerve-current undergoes a negative variation, which is added to the negative, but subtracted from the positive phase of electrotonus. Under the interrupted current, however, in which no original nerve-current is present, as shown when the nerve is placed in the galvanometer so that its equator is central, this negative variation fails to be marked.

But what renders most probable the idea of a negative variation of the natural nerve-current taking place, when a nerve is in a state of action, is, that on passing strong, quick, alternating currents pretty rapidly through a portion of a nerve, so that every such current is opposite in direction from that which preceded it, such as Faraday's *current of induction*, as obtained from galvano-magnetic and magneto-electric machines. Now, if the electrotonic increase were exactly the same in the positive and negative phases, there would be no effect on the needle, for equal forces acting in both directions produce rest. But as the variation in the positive phase is greater than that of the negative, from the effects of the continuous, primary, or voltaic current, if the action of the induced current on the nerve be the same as that of the primary, there ought to be a slight needle deflection to the positive side. This certainly should obtain when the strongest-way working of the induction-current is so applied as to run *with* the natural nerve-current. Notwithstanding this, however, the current may be applied, and, if strong enough to produce a result, the electrotonus, brought about by quickly alternating currents, shows the deviation of the natural nerve-current to be negative, in a very marked degree; for in the tetanized nerve, the same as after labor, the characteristic phenomenon is expressed by a *negative variation* of the natural current. We conclude, therefore, if the tetanized nerve is identical with the physiologically *active* and *acting* nerve, — and we are entitled to assume that it is so, — then a negative variation of the natural nerve-current is the physical expression of those further molecular changes which take place in a nerve when it produces a motion or a sensation. We must conclude, also, that the continuous electrotonic state differs from the physiological

condition of the active nerve; but the negative phase represents the state of fatigued nerves; as also anæsthesia, and classes of debility, and chronic-nervous exhaustion, and all those palsies, which occur without spinal irritation, or irritative brain lesion, or reflex excitation; while the positive phase of electrotonus represents hyperæsthesia, nervousness and restlessness, neuralgia, some kind of pain, and those palsies, with spinal irritation, or irritative brain lesion, or of reflex excitation.

As from labor some nerves become excessively fatigued, while others are but little so, just so in disease we may have some nerves and muscles in a state of positive variation of electrotonus, while others are in the negative degree; and perhaps others are undergoing those influences that constitute more or less of tetanus; so that in the same person, and at the same time, it is possible for us to see manifested two or more of these compound phenomena, which have heretofore proved so perplexing to be accounted for. And we conclude, finally, that the natural state of a refreshed and healthy nerve at rest, is in molecular arrangement, di-polar, and always represented by the condition of a closed current, i. e., simply prepared and *ready* for a tetanizing influence, which is only a rapidly alternating production and cessation of electrotonus.

The *after-effects* of an electric current, running along a nerve-trunk, are of two kinds, termed *dynamic* and *static*. The opening contraction is considered the first effect of a primary current. Ritter first discovered that this does not depend upon the current, but upon the succeeding changes produced in the molecular condition of the nerve. Pfluger corroborates this by showing that the resulting contraction may not occur for some moments after opening the current. Another effect of the constant current is the tetanus which occurs on opening a circuit after it has run through a nerve for a given length of time. Ritter first made this discovery; hence it is termed the "tetanus of Ritter." He supposed that this opening tetanus occurred with the centripetal current only, to which he accordingly ascribed an *exalting* influence; while to the centrifugal current, which he supposed to produce no opening tetanus, he attributes a *depressing* effect.

This is now seen to be not quite correct. So also Volta founded upon his observations the law known as "Volta's changes," which affirms that if the current runs with its own direction, (i. e., with the natural nerve-current,) an electric current *depresses* the irritability of a nerve; but if in the opposite direction, i. e., when run contrary to the native nervo-electric current, it *elevates* the irritability of the nerve. This, too, is now modified when applied to living nerves.

The facts are, as recently proved by Rosenthal, that the opening tetanus is not, as Ritter supposed, peculiar to the centripetal current, but occurs with currents of both directions, provided they, or either of them, have been a long time running through a portion of the nerve. However, the tetanus is less constant with the centrifugal current. Three stages of irritability are discovered from the form and intensity of the opening contraction. In the first, the opening of the current, which has been a long time closed, calls forth a powerful tetanus, which lasts from a minute to a minute and a half. In the second stage there is merely a strong contraction followed by slight shortening of the muscle, which lasts for some time. In the third stage, there is merely a contraction. The opening tetanus immediately stops when the current is again applied, but re-appears on opening it. If a current is sent in a direction opposite to that which has produced the tetanus, the latter is intensified; but on opening this reversed current, it disappears.

*The static condition of a nerve after the action of a voltaic current* consists in an exaltation of irritability at both electrodes, i. e., in the katelectrotonic as well as in the anelectrotonic tracts, with this difference, that at the negative there is a short interval of depression. Pfluger made this discovery; but this law holds only in the extra-polar tracts when applied to living nerves.

*The Molecular Mechanics of Nerves*, or the "*Evolution Hypothesis* of Pfluger."—The fundamental idea of this theory is, that the progressive molecular movement in a nerve sets free, at all points of its course, new forces, so that the sum of these forces is greater at the extremity of a nerve, along which an irritation has travelled, than at the point and instant of excitation; the

amount of force developed corresponding to the extent of nerve traversed. In the molecule, we believe, resides a force which is constantly tending to the production of movement; but this is opposed by a stronger, contrary force, which *controls* such a tendency. During the quiet state of the nerve, these forces, which may be termed *molecular tension* and *molecular control*, are equally balanced, and the latter is kept in a certain position, and to which it instantly returns when it has been removed from its position by other external influences or forces acting upon it. Moreover, molecular control may be pushed aside in either of two opposite directions. If in the one, the result is *the production of living force*, — the amount depending upon the extent to which the molecular control is put aside; if in the other, the result is *accumulation of tension-force*. So, in order to illustrate this setting-free hypothesis, it must be conceded that the following premises are granted: —

An electric current which is made to traverse a portion of nerve affects only *the force of molecular control*, not that of *molecular tension*. The change produced, then, on the control-force, by the current, consists, simply, in this: that in the region of anelectrotonus this force is increased, in the region of katelectrotonus it is diminished. Hence a positive increase of control-force induces, indirectly, a positive increase of tension-force; and reversely, a negative increase of the one with a negative of the other. Such are the more recent views of Dubois-Reymond, Pfluger, Rosenthal, Funke, and other prominent observers in electro-physiology.

Another proposition, that of Eckhard's, is, "Every constant current that flows through the motory nerves occasions on the traversed part, and that lying above the positive electrode, a diminution of excitability, while, on the other hand, the excitability increases in the part situated under and beyond the negative electrode. Moreover, that the excitability is *always* increased underneath the negative electrode of the circuit *when* it is so situated as to work at the upper end of the nerve in a downward direction."

Dr. Heidenhain subjected these opinions to a series of rigid

trials, and concludes, without however being aware of Marianini's results, that a muscle, or group of muscles, which, either from straining, extreme heat, or teasing by abusive induction shocks, (or by any other means,) has been deprived of its excitability, regains its power of contracting by the aid of the steady continuous galvanic current, and that more rapidly by means of the up-running current than when its course is downwards.

Dr. Pflüger, on the other side, subjected others of M. Echard's experiments to trials, and he concludes that the stream fluctuations of a constant current do not produce equal *shortening* of the muscles, or portions of the muscles, through the whole extent of ramification of that nerve through the muscles; but that *the contractions grow stronger in proportion as the irritation is applied near the central end.*

If, now, says Dr. Remak, we keep an eye on this result, and then test the relation a nerve bears (while the central end is coursed through by a steady down-running current from a moderate battery,) to electric current fluctuations, we shall find, as Dr. Eckhard has already observed, the ability of the nerve to respond by the visible contractions of the depending muscles to the fluctuations of the current, and that to increase below and about the negative electrode, while this increase is found diminished again farther on towards the periphery. And second, we find that a constant steady current, which runs *down* the nerve in the neighborhood of the muscle, to operate quite differently; for it exerts its influence also upward, and occasions a decrease of the contraction or twitching produced in the neighborhood of the positive electrode by the fluctuations of a down-running current; but said *decrease* becomes less towards the top, and ceases altogether before the end is reached. Third, if the central end of a nerve is coursed through by an *upward* current, we shall find, it is true, that the susceptibility of the nerve and muscle to fluctuations of the current decreases below the positive electrode; but it is also true, that this diminishes, and even ceases, before reaching the extreme part of the muscle. Fourth, and finally, if the steady up-running current operates in the neighborhood of a muscle, while at the same time a fluc-

tuating current of another battery is all the while working above it, and in a different current direction, we shall find, to be sure, that the twitchings, or muscle contractions, increase in the vicinity of the negative electrode; but it is also true, that this increase decreases again, in proportion as we approach the central end.

If we cause a feeble but steady battery current to travel *in the same direction* with the native nervous current, as through an isolated nerve, we immediately see that the latter is *increased;* while if the direction of the two currents are *opposed*, — the artificial to the natural, — then the native intensity is found *diminished.* Either of these conditions can be thus maintained as long as the projecting portion of living nerve experimented upon is traversed by the gentle steady voltaic stream to certain limits; but they cease immediately when the latter current is removed.

It is thus determined that by means of the circulation of a foreign current through the trunk of a nerve, there is brought about an alteration in the entire nerve, even with its extended branches included. This alteration M. Dubois-Reymond calls the *electro-tonic state* of the nerves. It is also called *electrotonus.* He gives two forms or phases of this induced state of the nerves: the one is where the original nervous current receives an augmented intensity, which he calls the *positive;* and the other is where the nerve suffers diminution of the native nerve current, and this he calls the *negative.*

From the study of these phenomena, we may explain by supposing that the electro-tonic state which the nerve is caused to assume is due to the molecular polarization of the nerve, analogous to that which is always determined in all conducting bodies from the one-way passage of any electric current. This polarization simply consists in the fact that the molecules of the nerves, naturally endowed, as they are, like those of the muscles, with two electricities, turn all their positive poles towards, or with the way the foreign voltaic current is going, while all their negative poles are towards from whence it comes. The molecules of the nerves are supposed to be bi-polar, and arranged as in muscles and other fibre. This explains the manifestation of

the nervous current, which is in the same direction with the muscular current. But under the influence of the *exterior* voltaic current, the nerve molecules being more *mobile* than muscle molecules, they arrange themselves, one after the other, according to the true mode of polarization. This condition is assumed even in portions or *branches* of the living nerves that are traversed where these twigs *are not directly* traversed through by the current. This action is called *extra-polar working*, and has a tremendous bearing, as we shall have occasion to observe, on the every-day results obtained in systematic electro-medical practice.

There is obtained from these microscopic results and philosophic deductions *a law* that there results, from a foreign or galvanic steady current actually coursing for a given time through a nerve trunk, *an abiding influence*, which causes an *increase* or *diminution* of the active native electro-nerve current, and that according as the artificial current was made to bear upon the nerve, whether directed *against* or *with* the native current — whether often or seldom *reversed* or *repeated*, or long *continued*.

Again: if the nerve is placed between two clean platinum plates which serve as the poles of a very gentle but finely interrupted induction current, and hence alternating in rapid opposite directions and in regular succession, there is a tetanization produced. On suspending this artificial current, after a short time we see that the galvanometer indicates a decided *diminution* in the nerve current proper in that living part, whatever may be the so-called direction of this exterior current; whilst, with the continuous and even stream of galvanism, continued for the same length of time, we get an *increase* in the living electro-nerve current, i. e., when run in the same direction with it; but there is a *diminution* of the living electro-nerve current proper to the living organism in health when the artificial current is directed in the contrary direction, i. e., against the natural nerve current.

There is an important difference, then, to be observed between the tetanizing of a nerve and that of a muscle; the electrotonus in the muscle being the result of a weakening or a nega-

tive variation of the native electro-muscular current, whilst that in the nerves is connected with the appearance and the cessation of the electro-tonic state, which is alone produced and maintained by the rapidly interrupted, and as rapidly and regularly alternated, electric current of induction. M. Dubois-Reymond has shown in this connection that the electro-tonic state of the nerve, excited directly, determines also *in the neighboring* nerves and their branches an electro-tonic state; *but exactly the reverse of its own.* This has a significant remedial worth, to be borne in mind in connection with this practice, that comes under the head of *extra-polar workings* of the current.

It has been proved satisfactorily that whatever be the portion of any sensitive or motor nerve, that is positively polarized, there is immediately manifested a negative variation of the natural nervous current in all the remaining or unincluded portions of that nerve, — a proof that the new influence is propagated through all nerves in all directions equally. This solves the great question, whether, in each class of nerves, the natural nervo-galvanic current is propagated only in one given direction, as from above downwards in the motor nerves, and from below upwards in the nerves of sensation. All kinds of nerves, then, as we have shown, conduct electricity in the same manner when under the influence of the foreign, galvanic, or Faradaic currents. We can recapitulate and sum up the following condensed conclusions, much in the words of the great modern philosopher, M. De la Rive: —

1. We may regard as demonstrated, and that in a decided manner, from a multiplicity of prodigious researches, that there does exist, both in the nerves and in the muscles of all living human beings, and in living animals, a *natural electricity*, under the influence of a *vital force* that is as ceaseless as life, and in some degree, at least, independent of mechanical, physical, or chemical actions, whether exterior or interior, although it co-works with them.

2. That this native or animal electricity is manifested under the form of closed currents, circulating along the course of the muscles, or along the course of the living nerves, but of which

we are able to collect only the smallest *appreciable* portions by the assistance of our best instruments.

3. That the presence of this *free electricity* is subordinate to the state of the life and well-being of the person or animal, and that it totally disappears, together with the vital force and all vitality, at death.

4. That in the nerves, as in the muscles, there is an electric antagonism between the transverse course, which is negative, and the longitudinal, which is positive.

5. That a great and sudden diminution is observed to be brought about in the animal current of the muscles, at and after the moment of powerful contractions; and also in that of the native current of the nerve, at and after the transmission of a sensation or motion.

6. That the negative variation of the muscular current *is not permanent*, even when the contraction is so, or rather seems to be so, as in artificial tetanus — a state that is composed in fact of a rapid succession of simple and sudden variations of intensity; that the muscular current does not recover its intensity immediately, but gradually, and that after the contraction, or the electrotonus, has ceased.

7. That the electric phenomena in the nerves of motion, and in those of sensation, are for the most part identical; both of these kinds of nerves transmitting the artificial galvanic current of electricity in both directions equally well.

8. That the nerves differ from the muscles in their electric relation in that, when the former are traversed in but a portion of their length by a continuous current of galvanism, *the entire nerve* assumes an electric or *polar state*, which is termed electro-tonic; whence results the production of a current that, according to its direction, either increases or diminishes the effect of the ordinary natural electro-nerve current. Then this electro-tonic state of the nerve, that may also be imparted to its depending muscles, is a commencement of electrolization; it thus brings about a contraction, both by its arising or appearing at the moment when the circuit is made, and then by disappearing again at the moment when the current is broken.

If now we compare together these facts, that are proved by our electro-physiological experiences thus far, we find that we arrive at some further very remarkable and valuable conclusions; and first, we observe that when we act by means of a strong, steady, primary current, upon the nerve trunks of a living person, then there is, at the very commencement of the trial, a contraction of the limb, and a manifestation of real pain; and this also at the moment when the circuit is broken, as well as at the moment when it was closed or made; and that these results obtain, whatever may be the direction of the current employed.

But on continuing these trials for a certain longer time,— shorter in proportion as the current employed is the more intense,— we find that there exists a difference between the effects, according as the current travels in the one direction or in the other, and according also as the circuit is closed or opened. When the current is directed *downward*, i. e., from the head and spine in the direction of the ramification of the nerves, the effect is limited to the contraction of the muscle, muscle group, or whole limb, *at the moment when the circuit is closed.* And when the circuit is again *opened*, the effects are limited, or mainly directed to the contraction of the muscles of the back, which are accompanied with pain. But if the poles of the battery are now reversed, so as to send the current in what is called the *inverse* direction, or *upwards*, i. e., towards the spine and brain, and thus contrary to the nervous ramification, then the order of the phenomenon is not only reversed, but also modified. The *closing* of the circuit now, causes the contraction of the muscles of the back, which is accompanied with pain, while the *opening* of the circuit is attended with a contraction of the muscles of the limbs.

Thus there are found two fundamental states or periods of vitality in the nerves and nervous system of man, entirely independent of those states brought about by the prolonged or abusive use of different treatments, which, from the mere temporary action of the artificial galvanic current, gives two classes of results. In the first condition the current acts readily in both

directions; that is, at the closure of the circuit, during the continuance, and at its opening. In the second condition, it acts mainly at its *commencing*, if running *with* the nerves, but at its *ceasing*, if running *contrary* to the nerves.

Again: if we find that a *stabile* and somewhat strong galvanic current is able to produce pain, together with contractions in the muscles of the back and head, and this even when the current does not act *directly* upon a nerve that ramifies into these muscles, thus, indeed, bringing about a motion at will, purely by the power and skill of the electric excitation of the nerve or nerves, situated *above* the excited part, then we conclude that this result must be due to that action which Marshall Hall has designated as *reflex*, or reflexion, — an action which is due, in the first instance, to the sensorial excitation of the nerve upon which the current *directly acts*, and this bringing about the contraction through the intervention of the nerve centres; as, for instance, from the periphery sensory nerves thus telegraphing back the answer through the motor nerves. And here lies the broadest and deepest channel for the introduction of those yet to be discovered electro-therapeutical operations. What we already know of them is not only invaluable in itself, so far as it goes, but is also rich in promise, though as yet, we believe, it has received no adequate attention. Marianini, Matteucci, Marshall Hall, Dubois-Reymond, Becquerel, and Brown-Sequard have in vivisections severed the spines and otherwise mutilated the bodies of a thousand animals, and thus fairly established this mysterious, but as yet scarcely comprehended *fact*. Let practical men and lovers of science observe and study this *law of electro-reflex action*.

But again: it has been observed that when actual death has been produced by a bolt of lightning, the excitability of the nerves by the electric current entirely ceases; yet it is often found that in these same cases the excitability of the *muscle fibre* remains. M. Matteucci remarks that no poison can diminish the excitability of the nerve trunks and branches like *hydrocyanic acid* and the *curara poison*; yet in these cases the muscular fibres retain their irritability to the immediate application

of electricity. This will now and then be observed, as the author has certainly experienced in his practice, in certain cases of paralysis; i. e., where the large nerve trunks give no response to any kind of electric current that is brought to bear upon them, while at the same time the depending muscle groups supplied by that nerve readily contract, and where there is also a given *sensation* response to the direct application of strong currents of induction.

Alexander von Humboldt was the first to attempt to show, as he then thought he could produce by the voltaic current, contractions in a piece of fresh-cut muscle, deprived as much as possible of its nerve filaments. Müller, and Matteucci, and others followed up his researches here, until they, too, concluded that this kind of contraction can take place at the instant when the current commences to pervade the muscle, and at the moment when it ceases to circulate in it; and this whatever be the direction of the current relative to the course of the muscular fibre. They concluded, therefore, that the electric current alone, of all the agents tried, when it is applied directly to the naked muscle by the polarizing and more completely arranging and compacting the muscle molecules, is able, in the aggregate, to result in the shortening or contracting, *even without the intervention of the nerves*. But we must also bear in mind how difficult it would be to *exactly* obliterate all nerve filaments of matter from the mass of muscle, while the resulting effects of the current under the given circumstances may be unquestionably correct.

But we have ascertained that the nerves do possess in themselves a certain electrical state. We know, moreover, that this electric state is modified by every kind of excitation there is produced through the nerves. We know that the muscles have likewise a natural electric state, which, too, is modified every time there is a contraction. Now, in the absence of excitation in the nerve and of contraction in the muscle, there must be a certain equilibrium, *which consists* in the circulation of native internal electric currents, together with the minute chemical processes there going on, the first and controlling cause of which

is, the *vital force*. This gives to all organic molecules, which are naturally bi-polar, the arrangement necessary to the establishment of these natural nerve and muscle currents; but when once established, they are probably reciprocally sustained, that is, self-sustained by the said chemical action, that is as every where present in the body as life itself, accompanies vitality, and which it perhaps, in part at least, again of itself determines.

Thus is life transmitted by the nerves through means of their nervo-electric state, as found in their normal or healthy condition of vitality; and from this there results, in all the muscles and tissues of the living human organism, an analogous electric state and process, but with certain differences, due, as we have shown, to the different nature or function of these divisions of the living body. When the natural electric state of a nerve is modified by any cause whatever, the equilibrium is destroyed, and there results some sort of sensation or contraction, or, more usually, both. When this arises from the nervous centre, it appears that the polarization of the telegraphing nerve then on duty is brought about longitudinally; i. e., from one extremity to the other, just as is every conducting body that is traversed by an electric current, in such a manner that the negative pole of the molecules is turned towards the centre, while the positive is towards the muscles. This is just what would result from the action of a galvanic current travelling in the direction of the nervous ramification; i. e., from the head towards the muscles. This it is that explains why an electric current run in this direction, favors the contraction more than when run in the opposite direction. Then, again, if the influence exerted upon the nerve, instead of coming from the brain, rather comes from the muscles, the polarization of the nerve must take place in the opposite direction; so that the positive poles of all the molecules are turned towards the nerve centres, while the negative poles are towards the muscles from whence the excitation came. Hence a galvanic current run *towards* the brain produces more *sensation*, but, when down-running, — i. e., *from* the brain, — more *contraction*. Polarization is therefore established in a contrary direction in a nerve of motion and in a nerve of sensation. The

exception is where a compound nerve is tested with an electric current, or any way acted upon *in its course*, or in some part of its length; as, in that case, it may transmit motion towards the periphery, and sensation towards the brain, simultaneously, — its two portions being polarized in directions contrary to each other.

Electricity in the animal frame is, hence, *the force* by means of which all nervous action is exerted, — not created at the moment when the nerve acts, but preëxisting in the particles of all organic matter. While under the absolute influence of vitality or life, these particles are arranged in a special, methodical manner, so that life cannot be considered as a *consequence* of the electric nature and arrangement of these molecules; but *life* must, on the contrary, be regarded *as the cause of their mode of grouping*, and consequently, indirectly, of the phenomena that result. Let life but be taken away, the particles still preserving their electric polarity and property, — i. e., their simple polarity, — and they are found grouped now quite differently. Here, they simply obey the forces of equilibrium that are proper to them, and present nothing but the ordinary phenomena of inorganic matter. Such is a dead body.

According to M. Matteucci and Alfred Smee, the *cause* of natural currents of animal electricity *is to be attributed to the chemical action that is peculiar to living organisms*, where arterial blood is in contact with the tissues, and consequently in the living voltaic arrangement for the life, nutrition, and repair of all the tissues, &c.; while Dubois-Reymond and De la Rive teach that these are *subordinate to* an undefinable *vital force*, and that the nerves in man are endowed with native *nervo-electric currents*.

We find, as is well known, that if we take a frog, and place a small bit of the *curara* poison, as by vaccination, just under the skin, the frog is soon killed. If, now, we electrize the large nerve trunks, we find they are dead; but if we touch the *muscles* with one of the electrodes, and that even with the weakest currents, they twitch most violently; and this lasts longer than when the animal is killed by other means. Claude Bernard is far from believing, however, that this is evidence of the inde-

pendent irritability of the muscles; but, rather, refers the phenomenon to such as where the nerves die in direction from the centre to the periphery, as evidently occurs in some central palsies, and also where there is death from chloroform. This, however, is questioned. Yet we can easily perceive that in any case where there is this partial effect or *state*, we shall find the electrization of the muscle substance to produce more decided effect than can be produced even from the exact nerve *border point*.

But it must be foreseen that the simple local excitement of the muscles by electric treatments, or by any other means, will never subject them again to the dominion of the will, so long as the nerve conductors from the central organs to the periphery are *un-toned*, and unless they are quickened by some natural, or adequate artificial action. To this end, Duchenne's method sometimes fails. Operating through the exact muscle border points, even, is not always a sufficiently sure exercise of the large nerve trunks. My custom is, therefore, in examining *such cases*, not to omit tracing from place to place the course of the largest nerves upon which the diseased part depends.

At a meeting of the Academy of Sciences, in Paris, M. Arago read the following notes from the illustrious Baron Humboldt, relative to muscular action and animal electricity: —

"Neither the jeers of certain editors on German credulity, nor the negative results obtained by two of our first natural philosophers, have changed my convictions regarding the influence of muscular action on the movement and direction of the galvanic needle. We have recently repeated our experiments at M. Dubois-Reymond's, and I invited M. Mitscherlich to attend, knowing his great dexterity in the management of delicate instruments. On giving tension to the muscles of the left arm, the needle was instantly made to move by M. Mitscherlich, and that in the direction predicted by M. Reymond, namely, indicating a current from the hand to the shoulder of the arm which was in action. On stiffening his right arm, M. Mitscherlich found that the needle moved in an opposite direction, and traversed a smaller number of degrees; this arises from the fact that the energy of muscular contraction is not, under all

circumstances, the same in both arms. Occupied, as I have been, for more than half a century, with physiological researches of this kind, the discovery of M. Reymond has most deeply interested me. It is a vital phenomenon, rendered sensible to us by an instrument of physics.

In connection with the same subject I may mention the result of some curious experiments recently made by M. Ducros. The conductors of a galvanometer were applied, one to the forehead and the other to the neck. The needle of it remained steady, and marked forty degrees. The patient's thigh was now strongly pinched, and under the influence of the pain, the needle passed to eighty degrees, with great rapidity. This experiment, frequently repeated, gave the same results; and M. Ducros hence concludes, "that all causes which increase vital activity, react on the galvanic needle, even at a distance from the point of their immediate action."

In *electro-dynamics* the theory of the transmutation of electrical into mechanical contractile force, so familiar and so fascinating to many physiologists since the publication of Grove's researches, is recently held up in a new light; or, rather, if the author understands Dr. Radcliffe, is reversed. On page 84 of his recent work he says, "Increased disposition to ordinary muscular contraction appears to be associated with diminished supply of blood to the muscular system." Then, in other parts of the volume, he endeavors to show that the relation of animal electricity to muscle and nerve in action, is that "*a loss of electricity is the cause of the action;*" while the natural electricity of a muscle *maintains* its relaxation, dilatation, and rest. He says, plainly, "*The state of action* in a muscle is accompanied by a discharge of electricity analogous to that of a torpedo;" and he believes that the primary electrical condition of living muscle and nerve, during *inaction*, is that of statical electricity, the nerve-current and the muscle-current being only secondary phenomena. He says, "When a muscle is made to contract by means of its nerve, there is reason to believe that the electrical discharge, (analogous to the torpedo,) which accompanies nervous action, has reversed the electrical relation of the exterior

and interior of the muscular fibres in the part acted upon; that this reversal has led to the discharge of the electricity which is present in the muscular fibres during the time of rest, and which keeps these fibres in a state of relaxation so long as it is present; and that this discharge of animal electricity brings about muscular contraction *by leaving the muscle free to yield to the action of the attractive force, which is inherent in the physical constitution of the muscular molecule.*" Thus, contrary to the views of Brown-Sequard, he gives very little credit to the controlling influence of the brain, and the medulla oblongata, in preventing morbid excito-motor disturbances under reflex or peripheral nervous irritation, and utterly ignores the fundamental law of *conversion of force.*

Such views, in regard to the electrical condition of the living human system, would lead us to believe that it may yet be found practical, even most advisable, to return to the original and earlier modes of using static electricity as a therapeutic, viz., by insulating the patient, and retaining him in the air-bath, or *charge* of positive electricity. Finally, Dr. Radcliffe adopts the grand primary proposition of Dubois-Reymond, that "during inaction the natural state of living muscle and nerve is one in which the longitudinal and transverse surfaces of the fibres are in a state of *electrical antagonism;* the longitudinal surfaces being electrified positively, and the transverse surfaces negatively." And we see he includes the nerves in the same law. To explain this electrical antagonism, he proposes a new hypothesis; but why the molecules, and the nerve and muscle fibres composed of them, so preserve during health their limited range of electrical relations and arrangements, is as yet a problem that neither of our great philosophers is able to solve.

In a recent lecture delivered at the Royal Institute in England, Dr. Bence Jones says there are good reasons for believing that there exists within us, in addition to the mechanical or animal circulation of the blood, another, and a greater and more strictly *chemical circulation*, closely resembling, if not identical with, that which obtains in the lower divisions of animals, and in vegetables — a circulation in which substances

continually pass from the outside of the body into the blood, and through the blood into the textures, and from the textures into the ducts, to pass again into the blood, or out of the body, or into the absorbents, by which they are disposed of.

*Effects of Heat and Cold on the Nervo-Electric Batteries.* — It is no uncommon thing to have the working of a set of compound galvanic batteries diminish as much as one half by sudden cold weather, or increase one half *in effects of working* by a change to very warm air. For this we must be prepared. And of all agents which act upon the human frame, *variations in temperature*, if sudden and considerable, doubtless produce the most potent results. It is demonstrated that the functions of animal life are actually voltaic-like ; and it is possible that this view of the exhausting effects of extreme heat, and of the suspension of action from extreme cold, accounts for these familiar facts. Indeed, from actual experiment it is shown that the phenomenon of life is depending upon unceasing native electric currents, and that these are enormously influenced by heat and cold.

Heat first excites ; then, if intense or prolonged, it exhausts the powers of the part or whole of the animal on which it acts. Cold first increases respiration, but a greater degree depresses, then, at last, even to total inaction ; so that there is not only cessation of feeling and of motion, but even of life itself. Variations in temperature act more powerfully than we are apt to think upon the whole electro-nervous apparatus of our organism, and hence affect the cerebro-spinal axis. Thus heat and cold affect pains, delirium, sleep, inflammations, and all those conditions and diseases in which the electro-nervous power is mainly concerned. In nervous restlessness or sleeplessness, if cold water is applied over the top of the head, or sponged over the whole body, until some little chilliness is produced, a good sleep will often follow, even where all nervines and narcotics have failed.

Heat is constantly generated by the ceaseless *vitalized* electro-chemical actions taking place in the peripheral battery of the animal organism. In fact, it appears demonstrated that the body is warmed by the changes that are ever taking place all

over it; and the changed matter that is the product of this, is simply *eliminated* by the lungs, kidneys, and other organs.

Sir Edward Holmes showed, long since, that if the nerves of a stag's antlers are cut across, the heat in the antlers is increased. When the spinal marrow is divided, we find the heat of the parts, from which the nervous supply is cut off, almost invariably rises, at least for a given time, to several degrees above the temperature of the inner part of the mouth. The peripheral battery, in health, is evidently kept in due subjection by the central battery; and if the two are by any means severed in any part of the body, the action beyond that spot appears to run wild and uncontrolled, until it runs down to fatty degeneration, atrophy, or to palsy, and then to death. All this is familiar to physicians who see the various cases of *early* traumatic paralysis. But after the abnormal heat, the muscles rapidly waste away, and then there is deficient heat. Also, as part of the phenomena, we observe large quantities of animal matter in the urine, showing that no small *change of matter* is taking place. Indeed, this abnormal rapid work and extensive change of matter appears to be precisely similar to that observed in an ordinary galvanic battery, where there happens to be no resisting medium to the pairs in each cell, but the action is, as Faraday would say, "*immediate*," *local*, self-devouring. Besides, may not *this phenomenon*, when circumscribed in effect, constitute what we call local *inflammation?* and, when general, constitute *fever?* Compound galvanic batteries can be variously *modified* in their "immediate action" by unbalancing their materials.

To show what effect *excessive heat*, without fatigue, has on the living organism, as a whole, Professor Styles, of Vermont, has recently instituted some careful experiments, which show that the muscular system of an animal may be paralyzed by heat, while the nervous system is left intact. The following is a type: —

A rabbit is placed in a large glass jar, or bell-glass, of sufficient capacity for free respiration during the experiment. A thermometer is suspended in the jar, and the whole is immersed in hot water until the temperature of the interior of the jar is

raised above 115°, but not allowed to rise to 120°. Soon after this — a period varying with the size of the animal — it becomes restless, and respires more rapidly; the blood-vessels enlarge, and their pulsations are ascertained to be increased. The heart beats more and more rapidly; at length the animal utters a few cries, and then becomes comatose. The pupils are dilated, and in a few minutes become contracted; and now the animal is removed from the heated air. He lies motionless, but in a variable time, from a quarter to a half hour after the contraction of the pupils, the blood-vessels cease to be distended; the ears and mucous membranes, wherever visible, take a bluish tint, and respiration diminishes. Here, life is sometimes terminated with convulsions, but more frequently it ceases gradually. If the thorax is quickly opened, the ventricles of the heart are found rigidly contracted, or become so within five or ten minutes, with both auricles distended with blood, and manifesting fibrillar movements. Neither brain nor lungs are congested. The *venæ cavæ* are filled with dark blood, which is alkaline, and coagulates rapidly. The cut-surface of the ventricles are acid to litmus paper. The microscope shows the blood is normal, but the muscular fibres of the heart have lost their transverse striations. The *rigor mortis* comes on in one or two hours after death; the rigid heart now becomes relaxed and quite flaccid, and in a few hours more the odor of putrefaction is very manifest.

The effects of heat on the organism of cold-blooded animals is still more apparent. The circulation in the web of a frog's foot is temporarily arrested by a temperature of 115°; and when a live frog is thrown into warm water of the above temperature, all the muscles of the body become rigid in one or two minutes. If a limb does not share in the immersion, it will remain unaffected; or only that portion of the limb which is immersed becomes rigid. The thigh of a frog, with the sciatic nerve projecting, if immersed in water at 120°, will become rigid, while the foot can be convulsed on irritation of the projecting nerve. This shows plainly that the nervous system is less readily injured by a high temperature than the muscular system. But various other warm-blooded animals, if held in heated air, or

immersed in water at 115°, being held by the back of the neck, so that the head is above the water, and no injury is produced except by the degree of heat, show the same results. The larger animals, especially when allowed to respire cool air, although they panted violently, yet they resisted the fatal influence of the heated medium. But small animals, such as mice and rats, soon perished. In one animal, which had exercised violently in the efforts to secure him, on being immersed in a heat of 120°, the mucous membrane became pale in five minutes after; and in five minutes more, all the muscles of the body became rigidly and permanently contracted. The thermometer introduced into the thorax, immediately after death, in all these experiments, did not rise above 115°, but often gave one or two degrees below that temperature.

*Electrolysis and Catalysis.* — The *law* of electrolysis is this: that a similar quantity, as, for instance, one equivalent of electricity, always decomposes one equivalent of an electrolyte. The *law is general*, when the combination that is submitted, is composed of only two equivalents, but is *modified*, in cases where more than one, — and particularly so, where vitalized compounds are the subject of trial. This *law* is frequently masked by a crowd of circumstances that arise in electro-therapeutics. But if we set out with the idea, laid down in the outset by Faraday, that the electric current, which acts in electrolysis, is only the chemical, *transported*, or put into process of transportation from one particle or point to another, under the form of a current *acting at a distance* instead of acting only at the contact, then the *law* of electro-chemical equivalents is a necessary and rigorous consequence of this; for the same chemical force must decompose every where an equivalent of the compound body.

We may, therefore, conclude that *the law of electro-chemical equivalents is found to be justified within the limits of error of observation*, and that if there is a portion of electricity that traverses the liquid without producing appreciable decomposition, it can be only a very small fraction of the total quantity of electricity transmitted. But if the liquid acted upon is

in living tissues, then this effect is somewhat modified, provided, also, the current is moderate, for there may not be so much electrolysis as catalysis; i. e., there is doubtless here more of the work of *composition* than of decomposition.

The influence that naturally determines sensation and muscular contraction in the normal state, is now termed the "*nervous force.*" Formerly this was termed the *nervous fluid;* but this arose from an hypothesis, which, in truth, has nothing to justify it; but the *will* or *volition* is, before and above all, the great moving *cause* that in the normal state is capable of developing in nerves the nervous force, which transmits, or rather propagates, itself to the muscle, producing in them contraction and motion. Next to the controlling power of the will over the motor nerves is the action of electricity; then mechanical action, chemical action, heat and cold. But in its mode of action, electricity differs from all the other exterior agents in characteristics that are alone and peculiar to itself. Its great relative importance here is seen by its effects approximating so nearly to those which the will calls into action, and which natural effects we believe we are able to restore again to the dominion of the will, *under certain circumstances,* even when it has been in effect apparently totally lost.

M. Becquerel, the discoverer of the more true physiological action of the primary currents of galvanism; M. Dubois-Reymond, the discoverer of the most fundamental *laws* in electro-physiology; and M. Remak, who first put these into practice clinically, and thus gave a tangible starting point for "galvano-therapeutics,"— are names the medical world will yet more and more recognize and cherish. The latter, in speaking of his first bedside experience, says, "The results of my first applications of the galvanic current were quite contrary to what I and other medical men had been led to suppose." He observed that the constant current, when in reasonable strength, and managed with common sense, instead of "*necessarily*" weakening a nerve, or the excitability of a nerve, *could*, on the contrary, be so guided as to *increase* its excitability, to a certain degree, as is plainly shown in the sensitive nerves by an increased susceptibility even

to a weaker current; while, in the motory nerves, it is manifested by the *increased strength of the contractions* that are produced by the occasional interruptions of such an exciting current after a long in-working. He also early observed that the natural voluntary capability of a muscle, or set of muscles, to contract and act normally, is increased more rapidly after being first a little excited by moderate induction currents, as done in the usual manner for such treatment, and then using the steady primary current, directed, for a certain length of time, both through the nerve trunk and the afflicted muscles. To illustrate his particular views, he gives the following case: —

A man who had suffered for seventeen years from violent pains in the arms, hands, and feet, accompanied with swellings of the joints, especially of the fingers; in fact, it was a case of old gouty rheumatism, with contractions and nodosities, of long standing, which had resulted in great helplessness, atrophy of muscles, and trembling in the limbs. When the patient was undressed, there was a visible wasting from the shoulders to the hands, and that with oscillating motions in the flexor muscles, which were soft and flaccid, with the exception of the *biceps*, which was, on the contrary, so hard and contracted that the extension of the arm, or the lifting of it above a horizontal position, was quite impossible. A *seance* was decided upon. "Some thirty-five elements of Daniell's batteries were switched on the key-board, and, by means of small brass-ball electrodes covered with wet wash-leather, this current was applied through the shoulder and arm, in all for about six minutes, as follows: First, *from* the nerve *thoracici to* the nerve *circumflexus humeri* for one minute; then *from* the same point to the anterior portion of the muscle *deltoides* for one minute; then from the *deltoideus posterior* to the nerve *circumflexus* and *fossa supra-spinata* for one minute more." It will be observed, he says, that the current had so far been running mainly in an upward direction, with only some changes of position for the electrodes, and with momentary recesses. Now, the patient was required to try the motions of the arm, and it was at once evident that he could move it about easier; and not only so, but he could raise it bet-

ter, and with less pain and trembling. Again the electrodes were applied, the one in the *supra clavicula fossa*, while the other was on the lower portion of the muscle *biceps*, and now with a down-running current: thus it was let on for one minute. Then, after a recess of a few seconds, it was again let on in the same manner for one minute more. Next, the one electrode was removed to the upper and posterior portion of the *deltoides*, while the other electrode was planted on the lower third of the muscle *triceps*, and this, with an up-running current, was retained for one minute more. Thus ended the first *seance*.

But I should have mentioned that by this the patient was a little "suppled," and but a little. I also wish to remark, as he has neglected to do it, that when the electrodes are thus situated over a nerve trunk or bundle of muscle fibres, it is best to disturb them a little, certainly as often as every ten or fifteen seconds, in order to produce *variations of density* in the constant current, as advised by Dubois-Reymond; and if the one that is over the muscle is slid along, *not all the time*, but say from three to six times during each minute, so as to cross and embrace the different bundles of muscle fibres, the benefit is found to be all the greater. On the next day he says that patient was brought again to receive further treatment. "The *seance* was repeated as before, but he could bear now only twenty-five elements at most; but there was directed, in addition to the above, for each side, a current of sixteen elements running *from* the nerve *thoracici* in the *fossa subclavicularis to* the muscle *pectoralis major*, or that portion of it that lies over the third and fourth ribs. The patient is now evidently better; pain and trembling less;—to come the next day. Thus for a fortnight he was treated, first, two or three days in the one limb, and then the same in the other limb, and that with a general improvement, except in the enlarged joints of the fingers and toes. The patient has been able to be about for the past six months, and, instead of relapsing, is still decidedly improving every way to a high degree of health, with the only exception of the enlarged joints."

Dr. Remak introduces the following case to show again the

remedial effects of the primary current of galvanism, which is, perhaps, more familiarly known to some as the "constant current." The case was one of cramps, with a rigid persistent contraction of the middle finger of the left hand, which had from time to time gradually extended up the flexors of the arm to the shoulder, originating, according to the history of the patient, doubtless, from a central source. He therefore directed at first a current from fifteen Daniell's batteries, in his usual manner, through the shoulder muscles, when he observed at once that the up-running current produced in that arm a twitch at the opening of the circuit. This, he says, he always regards as a sign of *abnormal* hyper-excitability, not produced by the current, but a manifestation of an already existing susceptibility. He continued this treatment a little, when the arm movements were found to be loosened in every direction. Similar manœuvres were then repeated, as also a current run down from the muscle *pectoralis*, first to its insertion in the *humerus*, and then moving by gliding the positive electrode farther and farther down the arm by gentle hitches, — done every few seconds, — following the course of the muscle nerves; whereupon most remarkable bettering effects were found to have been produced. In the course of every two or three days the *seance* was thus repeated, always directing the variations of the current, he says, much through the broad-spread fibres of the pectoral muscles, which, in a word, was followed with very decided and lasting good results. He states that he introduces this case merely to show by the results thus obtained, the confirmation in practice of the capability of this current of galvanism to increase, (even in palsy, rigid contractions, and atrophy, *whose central source could not be doubted*,) and entirely restore again the normal action of those blighted muscles and limbs.

In order to render the electro-muscular contractions produced at the *seance*, in the paralytic, of lasting and curative service, he says it is necessary to change the gross, uncertain, and partial muscle-fibre contractions into actual *twitchings*, or strong together-drawings of all the fibres of a sick muscle, either through the aid of a sentient nerve which is simultaneously touched by

the current; or, if this cannot be done, try the manœuvring of the current after Volta's or Ritter's method, or such other polar alternations as will change the point of entrance of the current, so as to be first at this and then at that pole, whether the direction of the current is also changed or not. He believes that the closure of a moderate, primary current of electricity through the nerves, in any case of "paralysis from a central cause," produces a favorable result, only and *provided* that, at each closing and opening of the circuit, during the *seance*, we are careful to make that electrode that is over the more external or distant nerve ramification, to vary in pressure, or position every now and then, (i. e., every quarter or half minute,) so as to wave or vary the density of the current, both before and at each putting on and taking off the electrode from the skin.

M. Hildenhains has used the so-called constant primary current of galvanism for therapeutical purposes, and has reported some trials made under the auspices of M. Rayer. But here was used a very different apparatus, and this, too, in a very different method from Dr. Remak's practice. The former employed *Pulvermacher's chain*, which, we know, is composed of numerous small bits of copper and zinc, that are moistened with wine vinegar and then placed upon the patient, who wears them for some six to twelve hours together. Thus he aimed to make up by time with a weak current, what the latter sought to do by more active currents in a shorter time. But there appears to be no comparison in the results. The apparatus that Dr. Remak uses (a compound Daniell's battery) gives a very constant quantity current, with little heat, that is entirely under his control to wave, interrupt, or reverse at his will, and that with a power capable of changing the polarity of the deepest nerves, of producing the contraction of the muscle fibres, and the dilatation of the vessels; while the Pulvermacher's chain, being poorly made, and worse applied, is an inconstant current, working when and where it may happen. This probably was the origin of the once celebrated "*Christie's Galvanic Rings and Belts*," that so flooded our country. Dr. Hildenhains advised the placing of one pole of this pile on the central

organ, i. e., on the spine, while the other end of the chain, or pile, was planted on the diseased part. This was necessarily a failure. But, no doubt, if the current could have been uniform, and directed only for certain cases, this would have rendered essential service in many diseases.

M. Robert Remak made his pre-trials with constant or primary currents of galvanism, with reference to medical practice, first on his own person. It appears that he took some forty of Daniell's elements, and from such compound-battery he applied the current to his arm; but, finding this too painful, he then used only thirty elements. Thus, by trials repeated first on himself and then on others, he arrives at the following rules, (as he considers them,) which are condensed from his work: —

1. The conduction of a strong and somewhat painful current is required to be directed through a nerve trunk, in order to produce in a muscle or limb a *general* tonic together-drawing, or, in other words, a fair muscular contraction.

2. If a current, by coursing through a nerve, succeeds in producing a tonic contraction, then this contraction could have been produced whether the current embraced a greater or less extent of the trunk of that nerve. For instance: if we test the nerve *medianus*, it is sufficient to embrace between the electrodes only that portion of this nerve that lies along the border of the lower third of the muscle *biceps;* but the facility of the nerve excitement and the resulting contraction, *increases with the length of the nerve extent that is included between the poles.*

3. A tonic contraction can be produced by directing a weaker, steady, and continuous current of electricity through a nerve trunk, even in cases where, if the same stream is applied in a similar manner but directly *over* the muscles of that same limb, it is not able to produce even an opening convulsion.

4. A current can cause insufferable pain without a tonic contraction being produced; while in another person, or even in the same person at another time, that same current produces strong tonic contractions, and scarcely any pain.

5. The production of the tonic contraction is, however, generally facilitated by the same conditions which also make the "closing convulsions" lighter; and that is, by a sudden letting on of the current. But there are also cases where only after a moderate and partial removal of the electrode from over the nerve trunk, where it has been applied for the minute before, the tonic contraction commences in the reach of that nerve, and lasts as long as the electrode is thus lightly touching the skin with a moist contact.

6. From twenty to thirty of Daniell's elements are usually sufficient to produce a visible tonic contraction on the arm of a well man. But there are persons who require even double that number to show this phenomenon. When a tonic contraction is not produced at the first application of the electrodes, it usually appears on the second application; i. e., after the first application has been retained, and thus allowed one minute, or so, of in-working to quicken the nerve sensibility. This occurs in those cases where the current obtains only the lighter "entrance convulsions" when applied directly to the muscles.

7. Most young people, and all who have strong muscles, show merely tonic contractions in the reach of the nerve trunk that is traversed by the current. But the phenomenon can change in the same person on different days; i. e., the contraction can appear either in the reach of the so traversed nerves, or the contraction may show itself in the antagonistic nerve and muscles on the other side of the limb.

8. The *will* retains so much influence during the trial, that it *can*, when exercised, prevent the production of the antagonistic contraction. In such a case, however, the entrance of the current is generally followed by tonic contractions in those muscles and nerves, towards which the motive purpose is then directed; while, at the same time, the antagonists also experience tension.

9. Moreover, this combat between the flexors and extensors of a limb appears often *without any participation of the will*. In that case, it is seen that one of the contractions,

which is usually the flexors, will soon dissolve or wilt down again, and that while the current is still running, so that the *prevailing* contraction goes over into the extensors, or *vice versa*.

10. Where a tonic contraction is produced and maintained by a current coursing through a nerve, we do not succeed, by means of the will, to give superiority to the antagonistic contraction.

11. It is by no means probable, that the antagonistic contraction is merely the consequence of a psychological act; for we notice the phenomenon equally in those persons who are wholly unacquainted with the subject, or object, of the test. Yet it is equally true, that it is difficult for many persons to entirely avoid exercising the will, particularly at the moment when the current enters the nerve.

12. In those cases where the antagonistic contractions occur during the time the current is traversing the nerve *medianus*, the thought naturally arises that this is the effect of a current transplanted through the thickness of the arm, so as to act stronger on the accidentally more excitable *extensors* than it does on the *flexors*. If this explanation were just and sufficient, says Remak, then a direct excitement of the antagonistic nerve trunk ought to produce contractions only in the reach of its own ramifications; and the same should happen also when the excitement includes both nerve trunks simultaneously. But in apparent contradiction is the following: —

Where a current, when traversing the nerve *medianus*, produces extension, i. e., a contraction of the *extensor* muscles, so as to open the hand, yet we find, as soon as the nerve *radialis* alone of that arm is placed in the current, or where the *medianus* and the *radialis* are connected, as by a wet bandage, so as to be under the same electrode which is placed on the upper arm, there is then contraction of the *flexors*. The same working and effect are produced when the end of the wet strip is carried from any point on the nerve *medianus* that is included in the circuit, to any point or part of the extensor side of the arm or forearm, *below* where the nerve *radialis* runs out to its ulti-

mate ramifications. This same effect is sometimes produced when a wet strip is carried from the nerve *medianus* to the back of the hand or fingers. This *simultaneous* excitement of the nerves running out on the back surface of the arm and hand, when continued a minute or so, produces not merely a temporary, but also *a lasting, influence* on the tonic contractions. For if now the wet pad is removed, and the arm is perfectly dried, and the current is so directed as to course through the nerve *medianus* alone, we find we do not now get extension, as before, but tonic flexion; and it continues to act thus until, by repeated special voluntary motions, its extensors have regained their capability to respond to the excitement in the usual manner. It is quite necessary sometimes, after this trial, to rub the fingers and muscles briskly, to bring them back to their normal sensibility and capability.

13. However difficult it might be to find a common law for these paradoxical phenomena, it was highly probable that they could arise from some disturbance in the equilibrium of the central organs, as tonic innervation; or, perhaps, the excitement of the sentient nerves play a real part in the result. This latter suspicion was all the more confirmed by this, viz.: that, after the current was made to traverse the nerve *radialis superficialis*, — which is a sentient nerve branch, — near to the radial artery, there is then occasionally produced an extension of the hand; and yet this effect is not apparent when the electrode is not on, or is removed rather to the one side of that nerve, even if but a trifle.

Such results obtained as pre-trials on man were then followed by the following trials and deductions: first, a current running in a downward direction through the nerve *radialis superficialis*, produced the extension of the hand; when the current was turned so as to run upward through the same nerve, there was closure of the hand. In another person, in health, it was observed that when the current traversed the nerve *medianus* downward, there was pain, with tonic extension of the hand; but when turned to run upward in the same nerve, there was less pain, but now tonic flexion. Thus it seems, says Remak,

that no other explanation remained than this: *that these tonic contractions were really called in play by a central excitement*, which itself was caused by the action of the current on the *sentient* nerves; and that all those variations and differences observed in isolated cases arose from central variations mostly, but also in some degree from the variations in the susceptibility of the sentient nerves along the extent of their ramification — "*in a word, this is none other but a true reflex-action.*"

In 1858, he made other trials, and having already had much experience in the medical uses of electricity, both by *primary*, constant currents, (i. e., seldom broken,) and by interrupted *induction* currents, he seems to be confirmed in the opinion of the *main, central source* of these contractions. He cites the case of a woman who had long suffered from hemiplegia, in whom he succeeded in producing tonic contractions of the paralyzed extensor muscles of the arm, by means of the so-called constant galvanic current coursing through the nerve *cruralis* and its branches, on the praralyzed side.

The following trial, I think, is a very instructive one. If we take even a sensitive frog thigh, prepared after Galvani's method, and lead the current on to the nerve or muscles, not by means of fixed electrodes, but merely by *wet threads* hanging from the electrodes, or wire poles, we find that the *closing contraction*, and also all tetanus, are avoided. Mark that, for it is both instructive and suggestive. Even when a stronger current is employed does this hold good — an end that M. Matteucci appears to have greatly sought for, as thought by him so desirable for given purposes. But the same thing is observed when the solid electrode is *not pressed* hard against the limb, but is rather held but very lightly to it. Hence we may infer, that a certain pressure of the electrodes over the nerves and muscles is requisite to produce the appreciable varyings in the density of the artificial current, which again produces variations in the native animal electric current, and this brings about the increasing degree of muscle contraction.

These like trials make it highly probable, therefore, that the galvano-tonic contractions, caused by a constant primary or

secondary current, when directed through a nerve trunk, and observed in its depending muscles, belong mostly to those phenomena which are produced by variations in the density of the employed current. This explanation, moreover, throws light upon the fact, that a steady and somewhat protracted application of such a current as will cause a closing twitching in the nearest muscle fibres, — that is, in those portions that lie near to the larger nerve twigs, — forms a favorable preliminary to the production of such a contraction. Now, if the excitability of these fibres or their nerves is not considerable, the fibres remain motionless, i. e., after producing the closing twitch. But, if the excitability of these fibres or their nerves *is* considerably increased, then they will show, while under the action of the current, a fine and delicate trembling motion, and through this wavy motion of the muscle fibres, prevent the nerves from being affected in an equal measure. The nerve trunk will in that case be conditioned the same as if it were alternately brought near to and removed from the most dense current, without, however, being entirely out of the sphere of its influence; that is, the different parts of the nerve and muscle fibres will respond to currents of different density, on account of their possessing varying degrees of resistance; and again, that in proportion as the muscles are depending on that nerve, they take on a contraction which may be either *tonic*, i. e., without interruption, or whose actually existing variations escape observation from being covered up with the skin.

Furthermore, "it is demonstrated in the living human being," says Dr. Remak, "that a constant primary galvanic current, as from thirty to fifty Daniell's elements, when directed, say through the nerve *medianus* in a downward course, produces the more pain and less extension of the limb; while if an upward current is used on the same nerve, there is the less pain and more extension of the limb; and, moreover, that while such a current is so running through the nerve *medianus*, according to the rule, and perhaps causing at first an extension of the arm and hand, there may appear in the same case, sometimes, a dropping of the hand, i. e., during the action of that same current; and this,

again, may be quickly succeeded by a contraction, caused by a still further action of the same current. Again, where the electrodes are situated over the nerve trunk and its ramifications, in such a manner as to lead the current *obliquely from* the flexion side of the limb *to* the extension side, even if with a less current, there appears to be more effect than a stronger current produces when the current is directed so as to meet the nerve fibrils from without, inwards. And, again, while it is true that the skin offers a certain degree of resistance, still are we compelled to believe that the sentient nerves participate in the results that at first sight might be ascribed solely to the motor nerves; and, finally, that under certain circumstances, it requires but a relatively small fibre, nerve, or central excitement, to change a simple current closing *twitch* into a true *tonic contraction*. Electro-tonic contractions do sometimes appear to set in, without the participation of the sentient nerves, or of the central organs; but they manifestly more generally come from *joint effects* on the sentient and motor nerves, being manifested not only in the reach of the nerves excited, but also in the antagonizing muscles; and this phenomenon cannot be satisfactorily explained in any other way. The central in-working of the constant current, as appearing from the foregoing, and so far as made apparent by the galvano-tonic contractions, might be ascribed by some to the production of a variable sensation of *pain* in some cases; but pain in other cases does not at all appear."

Dr. Remak says his own experience has led him to view this class of results produced by the current, in the muscle fibres and through the nerve fibrils, as proceeding directly through and from the central organs, entirely independent of any pain excited by the current; and that there are also some other clear cases of galvano-tonic contractions, whose origin is exclusively central. To illustrate this he mentions the case of a woman who had been suffering for eighteen months with a complete hemiplegia of the right side, together with a total loss of speech, the results of an *apoplexia cerebralis* which attacked her in childbed. But after mentioning the various treatments she had received, without any good results, he then proceeds to say that when

he caused a steady current of from twenty to thirty Daniell's elements to be directed through the nerve *cruralis*, or its cutaneous branches, there appeared, after twenty to thirty seconds, involuntary movements of the palsied hand and fingers, that continued as long as he retained the application. Then, again, the same effects were produced from a similar treatment of the nerve *ischiaticus!* These effects were evidently not temporary, but enduring, from the fact that the patient re-acquired by degrees the natural influence of the will over those extensor muscles of the leg and arm, which up to that time had been totally paralyzed; and this bettering was all the more noticeable, as he, from time to time, called forth contractions in the arm from galvano-tonic reflex action "*by an up-running current through the nerve ischiaticus* — alternated sometimes also with the current run in the usual manner on the arm itself." He is of the opinion that this kind of battery in-working, through the thigh nerve, is of real and all the more *peculiar influence* for good, from the distance and direction of the thus produced reflex motions through the motory apparatus and powers; as shown, too, by the control the central organs afterwards permanently obtained over the palsied limbs.

Another important fact, that is obtained by him, both from these trials and from the treatment of many cases, which is a gain for therapeutics, is this — that a constant primary current, of a supportable and reasonable strength, directed through the nerve trunks and muscle fibres by means of metallic electrodes with wet coverings of buckskin or cloth, applied to the skin of a healthy person, *is far from producing any sort or kind of "palsying" influence whatever;* but, on the other hand, the *increased excitability* of the affected parts from the working of the current becomes perceivable in the *sentient* nerves, as shown by increasing pain; and under favorable circumstances, is shown also in the *motory* nerves by tonic contractions. If, therefore, it is almost impossible to derive, by means of the constant current through wet covered metallic electrodes, any other than the more vigorous actions of the muscles through nerves, it is clear that a *down-toning* or *paralyzing effect* is only to be expected or

obtained under the conditions by which M. Matteucci tried to accomplish it, viz., by means of wet strips of linen used as electrodes to let on the current in the utmost gentle and gradual manner possible, and to maintain it long, and then to take it off in the same slow and cautious way, so as to avoid producing any twitchings, or tonic contractions, by avoiding the least possible *approach* to interruptions, or variation in the density of the in-working constant current.

### *Effects of Electric Currents on the Brain.*

Dr. Matteucci has made direct experiments to discover the effects of the continuous current of galvanism when applied *immediately* to the uncovered brain.* For this purpose he employed a good tension current from a compound battery of some sixty pairs. When the poles were applied fairly to the respective hemispheres, he observed that the animal did not start; nor was there any visible effect when the cerebellum was touched. But as soon as the electrodes were directed to the *tubercula quadrigemina* and the *crura cerebri*, while the current was passing, the animal began to scream, and simultaneously all the muscles of the body and limbs were contracted and agitated. As soon as the current was removed, this phenomenon ceased also. Such are the naked facts, with a constant current. But it would be exceedingly interesting to pursue this subject by experimental research, if it could only be instituted without the objection of solution of continuity of such vital parts. True, Professor Weber has made some interesting investigations into the action of induction currents when applied directly to the brain of living animals, which, of course, are mutilated. But he found no marked effects, even when the sharp electrodes were thrust *into* any part of the great medullary substance. But as soon as this current was directed through the *tubercula quadrigemina*, then irregular convulsions are produced, which, he says, very much resemble clonic cramps, and such as are noticed in those

* Traité des Phénomènes electro-physiologiques des Animaux, Paris, p. 242.

patients who are suffering with certain existing disease of the brain. These movements did not appear uniformly, nor yet irregularly, in any or all the muscles, but rather in certain groups of muscles which are naturally — or, as we could say, are physiologically — combined in action, as by reflex influences. If these kinds of currents are brought to bear upon the *medulla oblongata*, tetanic convulsions are the consequence, much like those observed in persons or animals when poisoned with strychnine. The next phenomenon observed by Faradaizing the *medulla oblongata* was, the actual cessation of the heart's action. From these trials, Professor Weber thought we might yet find that, where clonic cramps are seen, there exists a disease of the brain; while, if tonic cramps are observed in a patient, there exists disease of the *medulla oblongata*, or spinal cord. But up to the present time, such conclusions are not entirely proved.

*The human brain is the organ of the mind*, the centre of intellectual action; the material condition, without which no mental act is possible, in this present life. The actions of that mysterious thin stratum of gray matter, of the convoluted surface of the brain, together with the deeper underlying white fibres connected with it, are altogether of the mental kind during health. The physical changes in these parts give rise to corresponding ideas, *et vice versa;* nor is it unlikely that every thought, however simple, is invariably attended by a change in this centre. Dr. Combe says, "The mind *sees* through the medium of the eye, and *hears* through the medium of the ear, just as it *thinks* or *feels* through the medium of the brain; and as changes in the condition of the eye derange or destroy the power of vision, without any alteration in the principle of the mind, the obvious inference follows, that in like manner may changes in the condition of the brain derange or destroy the power of thinking or of feeling, and yet the mind itself, or *soul*, remain essentially the same." But in considering this question here, we must simply investigate the laws which regulate the connection between the *mind* and its *organs*, without attempting to discover or theorize on the *essence* of either, or the manner in which they are united. The effect of disease, how to know it, to anticipate, and to cure it, must be our only theme.

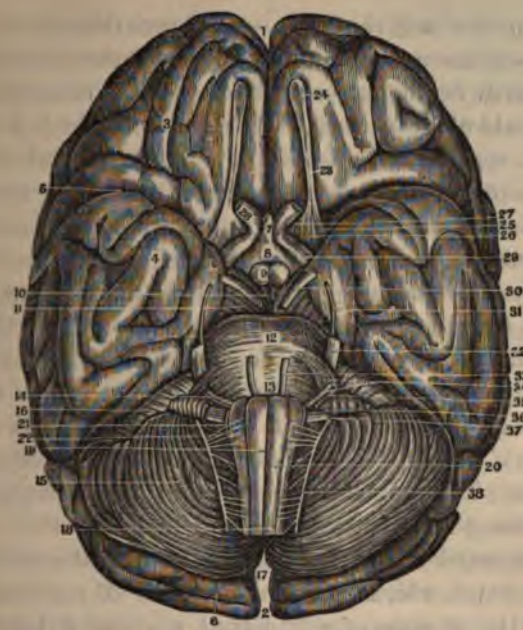


Fig. 21. A View of the Brain, showing its Base together with the Cerebellum, and their Nerves.

1. Anterior Extremity of the Fissure of the Brain Hemispheres.
2. Posterior Extremity of the same Fissure.
3. The Anterior Lobes of the Cerebrum.
4. Its Middle Lobe.
5. The Fissure of Sylvius.
6. The Posterior Lobe of the Cerebrum.
7. The Point of the Infundibulum.
8. Its Body.
9. The Corpora Albicantia.
10. Cineritious Matter.
11. The Crura Cerebri.
12. The Pons Varolii.
13. The Top of the Medulla Oblongata.
14. Posterior Prolongation of the Pons Varolii.
15. Middle of the Cerebellum.
16. Anterior part of the Cerebellum.
17. Its posterior Part, and the Fissure of its Hemispheres.
18. Superior Part of the Medulla Spinalis.
19. Middle Fissure of the Medulla Oblongata.
20. Corpus Pyramidale.
21. Corpus Restiforme.
22. Corpus Olivare.
23. The Olfactory Nerve.
24. Its Bulb.
25. Its External Root.
26. Its Middle Root.
27. Its Internal Root.
28. The Optic Nerve beyond the Chiasm.
29. The Optic Nerve before the Chiasm.
30. The Motor Oculi, or Third Pair of Nerves.
31. The Pathetic, or Fourth Pair of Nerves.
32. The Trigeminus, or Fifth Pair of Nerves.
33. The Motor Externus, or Sixth Pair of Nerves.
34. The Facial Nerve.
35. The Auditory Nerve, — the two making the Portio Dura, or Seventh Pair of Nerves.
36, 37, 38. The Eighth Pair of Nerves (The Ninth Pair are not here seen.)

*Disease, or lesion of the brain,* — of the convolutions of the hemispheres, — when it amounts to complete destruction, produces, not necessarily death, but protracted stupor. There is thus produced a state of deep sleep, with a retaining of full muscular power, yet apparently incapable of a single mental or nervous action, whether voluntary or sensitive. Hertwig removed the upper part of these hemispheres in a pigeon; sight and hearing were obliterated, and the animal sat in one spot, as if asleep. The muscles were but slightly enfeebled; the bird stood firmly, and would fly whenever thrown into the air. This pigeon lived three months. The brain of a hen was then cut away in both hemispheres, nearly to the base; when it was found deprived of sight, taste, and smell. It sat constantly in one spot, and was as if dead, until strongly roused, when it would move a few steps. The animal lived in this state of stupor, without its senses being restored, for three months.

This anatomy leads to the conclusion that this vast sheet of vesicular matter, which crowns the surface of the hemispheres, but which is so economically folded up, like a lady's fan, or more like the rich folds of full drapery, is where the sensorial impressions are not merely perceived, but are converted into ideas; and that here resides the power of directing, retaining, and concentrating the mind into a definite subject. Here is the laboratory of perception, calculation — the power of abstraction and imagination. It is here that all sensations take a form, and here leave lasting traces of their impression; "they serve as a seat to memory, and provide other property by means of which the individual is furnished with materials for his judgment." (*Cuvier.*)

When the membranes of the brain are in a state of inflammation, *disturbance* of the mental faculties is the result, and to an equal extent to the degree of cerebral irritation; and more especially so when, not the dura mater, but the pia mater, is the seat of the inflammation; because this membrane not only covers, but is attached to, the convolutions, and the blood-vessels of the gray matter are derived from the pia mater, so that the one cannot be affected without the other severely suffering. In

a practical point of view it may also be stated, "that in many, if not in most instances of violent delirium,— such, for example, as delirium tremens,— the vesicular matter of the convolutions is found, after death, to be bloodless, as if the accustomed supply of blood had been completely cut off from it. In delirium, after great operations, in that of rheumatic fever, gout, and other protracted fevers, this bloodless state is also found." (*Todd and Bowman.*) Most trustworthy reports of the dissections of the brains of lunatics show that there is invariably found more or less disease of the gray matter of the convolutions, presenting marked thickening, altered color, and change in consistence.

During health the hemispheres of the brain are insensible to pain, from mechanical division or irritation; in wounds of the head, in individuals still sensible, large pieces of the brain which had protruded have been removed without the knowledge of the patient. Nevertheless, pain is felt in certain diseases or injuries of the brain; but this results from a morbid state, propagated to other parts. The nearer a cerebral lesion is to the membranes, or to the medulla oblongata, the more likely it is to be attended or followed with pain. Headaches, of whatever nature, must be in one of two classes. First. They may be referred to irritation, either at their roots or at their periphery, of those nerves which are distributed in the dura mater or in the scalp; as the branches of the fifth pair, and of the occipital nerves, and of the auricular branches of the cervical plexus, are those most frequently affected. Some physiologists believe that all headaches, of whatever nature, are here embraced. Second. Those headaches which are not so situated must else be referred to the morbidly induced state, or altered function of the retina of ganglionic nerves that supply the pia mater and the gray substance of the convolutions, and the gangliform bodies at the base of the skull.

*Referred sensations in the head*, may occur from a morbid or actually diseased state, or may be produced by sudden changes of position of body, as lightness, heaviness, vertigo, or a tightness of the head, as if bound hard, or a sense of fulness, or of weight. Now, these are, no doubt, truly subjective,

arising from too little, too much, or an altered condition of the blood sent to the brain. A sense of giddiness precedes fainting, from too little blood. A sensation of a rushing of blood to the head, accompanies a state of extreme debility, which is owing, in part, *to the feeble tone of the arteries*, so resisting imperfectly the flow of blood to the head, and allowing it to impress the nervous matter too much.

In some temperaments, and peculiar conditions of the nervous system, the brain, or the mind, has the power of originating or exalting painful sensations in the head, as also in various parts of the body or limbs. If the attention of such persons be directed very strongly, and for a long time, to a given part, it may become the seat of distress, for which the most effective remedy is to thoroughly engage the thoughts on another point, or to some other object. And when pain has begun from a true physical cause, in many instances, doubtless, it has thus been prolonged after the entire cessation of the original cause. Hence it is plausible to suppose that, in such cases, the *perceiving* parts of the brain become, from this ceaseless practice, habituated to a certain morbid condition of the centre of sensation, first produced by a truly physical cause of the pain.

*The shape and size of the human brain* is too generally spoken of, and believed, among our American people, *as corresponding with, and indicating the talents and character of the individual.* That is, as taught by most phrenologists in this country the large bumps and size of the brain give the person the ability, with certain modifications; the want of these renders him and her incapacitated accordingly. Now, this doctrine, we believe, is carried altogether too far, in these days of exact science, for an intelligent community to hear, accept, and reiterate. It is a burlesque on science — a sophistry, not a philosophy. Medical men can, and should, correct this prevailing error. For more than twenty-five years we have publicly, and everywhere, opposed this dogma. General craniology and physiognomy are physiological and philosophical hints of ability and character; but beyond this the present knowledge of science does not lead us.

My own researches, and the testimony of most of the older

writers, and nearly every one of the more recent, all go, in the main, to show that even the weight of the brain, as a whole, of mentally-favored persons, and of highly intellectual individuals, cannot be proved, by actual comparison, to be any thing like uniformly heavier than those of the less mentally-developed persons; nor even of such as pass for dull, stupid, thick-headed individuals, — of course not including the idiotic, nor the demented. Dr. R. Wagner, a late writer on this subject, says he "found great development of convolutions, and great weight of brain, very often combined, but not always so." Our belief is, that a moderately-sized and fine-structured brain, rich in convolutions and cineritious matter, (which cannot be examined during life,) is more uniformly found to have been the source of prodigious efforts, of profound judgment, masterly accomplishments, and that indomitable perseverance that conquers a success, than can be associated with ten times the number of heavier, coarse-tissue brains, poor in convolutions and in gray matter, though larger in size, and displaying a large, rough, or bumpy skull. Nevertheless, generally we may diagnose, by a good-sized head of regular form, capacity, talents, and judgment; but we contend that all large heads are by no means uniformly talented, not even in any one thing.

*Disease or Lesion of the Cerebellum.* — When this organ is damaged so as to amount to a complete solution of continuity, the individual is in a condition similar to that of a drunken man, so far as relates to the power of locomotion. He cannot stand still for a moment, and in attempting to walk, the gait is unsteady; he totters from side to side, and is liable to fall if not supported. He is unable to produce that combination of action, in the different sets of muscles, which is necessary for attitude, work, or walking. Volition and sensation remain; the power of executing movements remains; but that of coördinating these movements into regular and combined actions is lost. If the cerebral hemispheres alone are utterly destroyed, the individual remains quiet and motionless, and still lives; but here, when the cerebellum is utterly destroyed, there is life, and an incessant restlessness, with an inability to accomplish any definite or regular movement.

The well-known experiments of Magendie, of dividing either crus cerebelli, show that the animal will roll over and over, on its long axis, towards the side on which the injury was inflicted. It would be difficult to conceive any other function for which so large and elaborate an organ would be necessary, excepting the regulating and coördinating the infinitely complex movements of the muscular system, in what it is seen capable of accomplishing. We believe that the cerebellum possesses the power of coördinating the voluntary movements which originate in other parts of the cerebro-spinal centre, whether these movements have reference to locomotion or to any other objects.

Medical students of these days, when searching for signs and seat of disease, must not be led by the old dogma, that the cerebellum is the seat of the generative instinct, as taught by Gall. He assigned the cerebellum as a special organ or centre of the sexual instinct; but it does not appear, from recent pathological research, that the cerebellum has any peculiar influence whatever upon the genital organs. Neither a relatively large nor small size of the posterior brain, injury nor disease of it, has any influence. The sexual passion must rather be ranked with the emotional and instinctive, such as self-preservation, a mental emotion. It would seem more correct, then, to refer this emotion to the common centre of all, than to a special organ. (*Todd and Bowman.*)

Many very curious and interesting experiments have been made, from time to time, upon the cerebellum with electricity; but I have nothing from them instructive or useful to record.

*Lesion of the Medulla Oblongata, Mesocephale, Corpora striata, and Optic thalami.* — From either disease or injury to the spinal cord in the neck, if just below the origin of the *phrenic* nerve, provided it amounts to a solution of continuity, such a patient will *appear* as a living head with a dead body. There is complete palsy of voluntary power below the neck, while the senses and the intellectual faculties remain for a time unimpaired; the sensations and the motor-power of head and face are perfect; respiration goes on tolerably well, and deglutition can be readily performed. Again, if the medulla oblongata

be irritated, it will produce, directly, spasms of the glottis, difficulty of swallowing, and irregular actions in breathing; while indirectly, if the irritation be propagated to the cord, it produces convulsions more or less general. That is, irritation of any part of the medulla oblongata excites, directly, convulsive movements in muscular parts which receive nerves from it; and indirectly, through the spinal cord, also convulsive movements in the muscles of the trunk and limbs. Complete destruction of the medulla is followed by the instantaneous and complete cessation of respiration. A lesion affecting only one half of the medulla oblongata excites convulsive movements, or produces paralysis on the opposite side of the body, if the lesion is above the posterior margin of the *pons;* but if below, it is not so certain, as results have proved contradictory.

Anatomy suggests that a lesion limited to either anterior pyramid would affect the *opposite* side of the trunk; for it is known that disease of it, or the continuations of it in the mesocephale, or crus cerebri, is followed by such effect. A lesion limited to the posterior half of the medulla, on either side, would affect that *same* side of the body, no decussation existing in those fibres; the irritating or the depressing influence of the given lesion, whichever it might prove to be, would probably be extended to the spinal gray matter of the same side. The frequent cases of paralysis of motion, apart from that of sensation, when the upward continuations of the pyramidal fibres in the corpora striata are diseased, render it extremely probable that those fibres are the media of connection between the brain and cord, in all voluntary actions.

The channel of operations of the brain, then, so as to be associated with the spinal cord in all voluntary actions, is proved to be the medulla oblongata, by the fact that paralysis of all the muscles of the trunk follows the separation of the medulla from the cord. Moreover, it seems probable that the centre of volition, or *will*, is primarily exerted upon, or arises from, those gangliform bodies, the corpora striata and the optic thalami, one or both, in which the columns of the medulla oblongata arise, or terminate above. And this power is all the more vig-

orous when guided by healthy cerebral hemispheres above all these.

The olivary columns of the medulla oblongata, at their upper and posterior part, being, as it were, the grand concourse of all the nerves of pure sense, are now generally considered as the seat of those central impressions which are necessary for sensation; and the reception of these impressions by the cerebral hemispheres is the stage immediately associated with mental perception.

Finally, we see that *the medulla oblongata is the centre of respiration.* Injury to it, any where from the roots of the vagus nerve to the tubercula quadrigemina, in whole or in part, invariably impairs or destroys the respiratory actions; a morbid state of it gives rise to irregular, depressed, or excited respiration. Sighing, yawning, coughing, and choking may sometimes arise, directly or indirectly, from this source.

A morbid state of this portion of the medulla oblongata, which is also the centre of action in the movements of deglutition, through fibres of *glosso-pharingeal* and *vagi* nerves, causes difficulty, or even paralysis, of deglutition. The distinct actions of respiration, and of deglutition, are both mental and physical, or either, they being influenced much by impressions propagated from the periphery. These movements may be, to a certain extent, controlled by the will; but after a few moments the physical stimulus is capable of conquering the restraining influence of the mind. The excitation of the medulla oblongata may also be started from the skin or throat, as through the fifth pair, or through the spinal cord, by the application of electricity, or by the sudden dash of cold water, or by the tickle of a feather in the fauces. So highly sensitive is the mucous membrane in this situation, that the slightest touch of it is sufficient to produce contraction of the muscles of deglutition which the will is scarcely able to control. Thus cough, from slight causes, is also more readily produced and maintained in one person than in another.

*Emotion*, and those actions which are influenced by it, have their *centre* in the medulla oblongata and its extensions into the

mesocephale. "The common excitement of movements of deglutition, or of respiration, or of sensations, referred to the throat, under the influence of emotion, evidently points to this part of the cerebro-spinal centre as being very prone to obey such impulses; and as the nerves of pure sense, especially the optic and the auditory, are very commonly the channels of sensitive impressions, well calculated to arouse the feelings, it seems highly probable that the centre of such actions should be near the origin of these nerves. The optic thalami may be viewed as the main foci of sensibility. This office is, therefore, in the vicinity of the quadrigeminal tubercles. The nerves which arise here, and from this region, are very readily influenced by emotion. Thus the third and the fourth pairs of nerves regulate the principal movements of the eyeballs, those especially which betray most quickly the emotional excitant; and the portio dura is the motor-nerve of the face, through which changes of countenance are effected. It may be added, that the centre of emotional actions ought to be so situated that it could most readily communicate with the centres of all the voluntary actions of the body, and with the immediate seat of the intellectual operations, as well as with the nerves of pure sense; and no part possesses these relations so completely as that to which we refer." (*Todd and Bowman*, p. 307.)

*The pituitary body* at the base of the brain is not a true encephalic ganglion, since, according to Dr. M. Michel, of Charleston, South Carolina, its complete destruction is never attended by loss of intellect, motion, or sensation, beyond what may be accounted for by the necessary pressure upon the surrounding more essential parts of the encephalon. So that while the diagnosis of its morbid state is rendered obscure by absence of its ascertained function, still the almost constant connection with the simultaneous production of amaurosis in both eyes, and with absence of symptoms of cross-paralysis, will indicate this the seat of the disease, when compared with morbid states of either hemisphere. Long continuance of disease, in this situation, may propagate inflammatory action to adjoining parts, followed by apathy, somnolency, syncope, cephosis, and other symptoms more obscure.

*The Spinal Column* is illustrated by Fig. 23, which is a lateral view. Having been sawn down through its middle, it shows its natural curvatures and internal structure.

Fig. 22. A View of a Piece of the Spinal Cord at natural size; showing the origin of some Spinal Nerves.

1. Shows the Anterior or Motor Root of a Spinal Nerve, such as are given off from the Cord, between the vertebræ.
2. Shows the Posterior or Sensory Root of every such spinal nerve; which, together, make it a *compound nerve*.
3. The Ganglion that connects each of these with the Great Sympathetic by a short route.

---

Fig. 23. The Spinal Column.

1. The Atlas.
2. The Dentata.
3. Seventh Cervical Vertebra.
4. Twelfth Dorsal Vertebra.
5. Fifth Lumbar Vertebra.
6. First Piece of Sacrum.
7. Last Piece of Sacrum.
8. Coccyx.
9. A Spinous Process.

10, 10. Intervertebral Foramina.

Fig. 23.

*The Brain and Spinal Cord* are shown in Fig. 24, which gives an anterior aspect of them, as extracted from their bony cavities. Fig. 25 is a posterior view of the Spinal Cord.

Fig. 24.

Fig. 24.

1, 1. The Hemispheres of the Cerebrum.
2. The Great Middle Fissure.
3. The Cerebellum.
4. The Olfactory Nerves.
5. The Optic Nerves.
6. The Corpora Albicantia.
7. The Motor Oculi Nerves.
8. The Pons Varolii.
9. The fourth Pair of Nerves.
10. The lower Portion of the Medulla Oblongata.
11, 11. The Medulla Spinalis in its whole length.
12, 12. The Spinal Nerves.
13, 13. The *Cauda Equina*.

---

Fig. 25.

1. Inferior Extremity of the Medulla Oblongata.
2. The Calamus Scriptorius.
3. The Posterior Face of the Spinal Cord, showing its Fissure.
4—7. The Posterior Roots of the Cervical, Dorsal, Lumbar, and Sacral Nerves, uniting with the Anterior Roots to pierce and pass out of the Dura Mater of the Medulla Spinalis, just outside of which are seen the Ganglionic Enlargement. Under 1 can be seen the sub-Occipital Nerve-Roots.

Fig. 25.

### *Effects of Electric Currents on the Spinal Cord.*

By the vivi-section of animals, Professor Weber has demonstrated, with the aid of electro-magnetism, that the spinal cord is the nervous centre of all the muscles of the trunk and extremities. If one of the electrodes of such a machine, with the current at maximum, be placed at the upper end of the exposed cord, while the other is directed to the lower end of the cord, we find that all the muscles of the body, or of the animal, are brought into violent tetanic convulsions. The same is true, if the electrodes are placed, the one to the anterior, and the other to the posterior roots of the upper portion of the spine, and even of the lower portion also, if it is yet intact.

Dr. Althaus justly says, if the spinal cord were simply the common trunk of all the motor nerves that emerge from the vertebral canal, then electrizing the lower part of the cord should produce a convulsion of the lower or hinder extremities, but not of all four extremities. If, however, the spinal cord is cut completely across transversely, and then only the lower half is Faradaized, the muscles of the lower or hinder extremities enter into contraction; and even if now both parts of the cord are made to touch each other closely at the transverse section, so that the simple passage of the electric current to the upper portion of the cord is easy, yet do the muscles of the upper extremities remain perfectly quiet. From this we may fairly infer, that the convulsions described are not produced simply because the electric current is *transmitted from* the cord *to* the motor nerves, but rather because the passage of the electric current along the spine *excites the action proper of the spinal cord*, which in its turn excites the property and office of the motor nerves to bring about commotion of the muscles. This species of reflex action is often as clearly illustrated in patients, who present for examination with uncertain lesions of the spine. Whenever tetanic convulsions are produced in the extremities, *by thus immediately Faradaizing the cord*, they continue a little after the electrodes are removed;

but if the anterior root, or even the whole mixed nerve trunk, is thus excited *at some little distance* from the spine, instead of applying it to the cord itself, the tetanic convulsions disappear the instant the circuit is opened.

Another fact: it has lately been observed by Dr. Baielacher, that if induction currents are applied to the large motor nerves of the hinder extremities of an animal, while the spinal cord is *at the same time* being traversed by a constant galvanic current, then commotions are produced in those muscles, the nerves of which are being traversed by the interrupted current.* Therefore he infers, that the diminution of excitability from the action of a continuous current is limited in the spinal cord, and hence does not extend to the motor nerves and their depending muscles.

Besides, if the whole spinal cord is caused to be traversed (i. e., lengthwise) by a strong, continuous galvanic current, it is observed that at the instant it commences to flow, there is a quick contraction in the muscles of all the limbs; but after that, and as long as the current then continues to flow *undisturbed*, even if for a long time, no more contractions appear; and the exposed spinal cord itself even, remains insensible to any stimulus whatever that may be applied to it; as, for example, pricking, pinching, heat, or induction currents; nevertheless all remains perfectly quiet. But, after the cessation of this current through the exposed cord of the mutilated animal, then again will the mere mechanical touch, or the reversed electrical excitation of the cord, give rise to twitchings of the muscles, and even contractions of the limbs, if the animal is still alive, and that in a greater degree than before. From such premises, surely, the author can never concur in the somewhat general opinion, that any considerable employment of the so-called constant galvanic current upon the human organism, *has necessarily, a paralyzing effect.* That paralysis, as well as a paralyzing tendency, can be produced by an injudicious use of electric currents, and that

* Die Inductions-Electricitat, Nurnberg, 1857, p. 102.

more readily by the galvanic, than the Faradaic currents, the author concedes. But, because the former has more power and uniformity of effect, upon and through the large nerve trunks particularly, is the reason why, when correctly employed, it is so greatly valued by the author as a therapeutic. In the most recent and popular work published in England on this subject, — and it is a most excellent work in many respects, — it is laid down as true, that "if the continuous galvanic current is allowed to traverse the spinal cord, then there is produced '*a paralyzing effect*,' whatever may be the point to which the poles are directed." Again: "The inverse continuous current [galvanic] is more powerful *for paralyzing* the spinal cord than even the direct galvanic current." Such, indeed, are the generally received views. Dr. Duchenne has also, in this direction, powerfully convinced the medical world, and greatly deterred from the employment of galvanism; but such views certainly do not accord with my own clinical experience, and therefore I cannot adopt them.

### *Tetanus.*

*Tetanus* consists not in an inflammatory affection of the spinal cord, or of its membranes, nor in congestion of them, but simply in a state of prolonged physical excitement, involving, also, a part of the medulla oblongata; the natural polar force of the centre being greatly exalted, and kept so by the constant irritation propagated to it by the nerves leading from the wounded part. A wound, especially in the sole of the foot, or the ball of the thumb, or in some other situation, is capable of thus exciting a segment of the cord, from which this state of excitement spreads upwards, downwards, sidewise, or so as to involve the whole cord.

This polar state of the cord, however, at least of a part of it, and to a limited degree, is sometimes, doubtless, developed naturally.* The most remarkable example of this is seen in the

* See Todd and Bowman's Physiology, p. 281.

case of the male frog, during the spring of the year, the season of copulation; the thumb on each fore-paw becoming at this season much enlarged, as is well known to naturalists. Large papillæ are formed all over the thumbs. A male frog at this season has an irresistible propensity to cling to any object that comes between its anterior extremities. Sometimes he may be found thus clinging to a bit of dead wood. It is in this way he seizes upon and clings to the female, fixing his hands, or thumbs, to each side of her abdomen, and remaining there for weeks together, until the ova have all been completely expelled. We see that an effort of the will alone could not keep up such a grasp, uninterruptedly, for so long a time. If so, he would tire; yet here so firm is the hold that it can with difficulty be relaxed.

If we place the finger between his anterior limbs so as to touch or tickle the inside of his thumbs, they will quickly and firmly grasp the finger; nor will they relax until separated by force. Cut off his head, and he will still continue to hold on firmly. The posterior extremities of the body may be cut away, and yet the anterior will still cling to the finger; but the moment the segment of the cord, from which these anterior nerves are derived, is cut, all their motion ceases. This curious instinct is simply an exalted polarity of the cord, which exists only during the period of sexual excitement; for at all other periods the posterior extremities of this animal are far more excitable.

*Cold*, for tetanus and polarity of the cord, is the most powerful and direct remedy. Nothing seems so absolutely to control this peculiar state of the spinal cord, nor so effectually or harmlessly, as cold. Ice crushed and applied along the spine, *persistently*, particularly over the upper portion of it, or the cold douche, may be generally resorted to with great advantage in all muscular disturbances when depending only upon this state of the cord. Primary galvanism from a dozen to twenty or thirty elements, applied in a steady, down-directed current, is also a powerful auxiliary, and by no means to be neglected when obtainable.

The "*cilio-spinal region*" is that portion of the spinal column included between the seventh cervical and sixth dorsal vertebræ. This term originated with Professors Waller and Budge, who first observed that when this region of the spine is strongly excited by Faradaic current, the impression is transmitted through the cervical sympathetic nerve and ganglia, (the roots of which emerge from that part of the spinal cord,) it then anastomoses with the nerves of the face, and also animates the *radior fibres* of the iris, and these act as the *dilators* of it. If, then, the cervical sympathetic nerve be excited, at the upper portion of the spine, by electric currents, the radial fibres of the iris very decidedly contract, as any *extensor* muscle, and thus overbalance, at least for the time, the circular fibres of the iris; for these latter, it is well known, act as the *constrictors* of it; and hence dilatation of the pupil must result. It is further found, that by the section of this particular nerve, the pupil of the eye becomes greatly and permanently *constricted*. The circular fibres of the iris, not being ramified by this nerve, are left to act in their normal state; while the section has caused in the radior fibres a complete paralysis, and consequently a preponderating, permanent constriction of the pupil of the eye.

*Coccygian Gland.* — This little, oval, yellowish-red body, recently discovered in man, is described by Dr. Luschka as of the size of a small pea, and is situated close to the point of the os coccygis, usually enveloped in fat, and largely supplied with both blood-vessels and nerves. It is little known as to its office, but it may be of much significance. A more accurate examination under the microscope shows that it is composed of five or six millet-like bodies, connected by loose tissue. They exhibit a stroma of dense fibres, between which are situated vesicles and tubes, single and divided, with bulbous ends. The blood-vessels are mostly derived from the *arteria sacralis media*, while some of them issue from the *rete arteriosum coccygium*. Like the suprarenal capsules, this coccygian organ receives an exceedingly large supply of nerve-fibres, which are given off either by the *ganglion coccygium*, or, when this is

wanting, by the loop-like communication of the lower end of the sympathetic nerve. Some of the nervous fibres in this coccygian gland have a club-like termination. Thus it would appear, that the great chain of the sympathetic nerve, as well at its lower end as at its upper end, is connected with a glandular organ — the upper with the pituitary body, the lower with the coccygian gland.

### *Effects of Electric Currents on the Organs of Sense.*

For operating on these, we may choose an instrument out of any of the *three classes* of machines that we employ for producing electricity, as all forms of it act upon the organs of sense, but differently, though all are admissible. From my own experience, and that after due consideration, I am disposed to decide that the primary galvanic currents have the most marked and beneficial effects on these delicate organs when they are deranged and diseased. I am not alone in this important observation, and if most effective and remedial here, why not elsewhere in the organism?

1. *Seeing.* — The normal action of electricity on the organs of sight, i. e., in health, is varied according to its *form* and *application.* If static electricity is applied by sparks *drawn* from the surface of the closed eyelids, there is produced not only the redness of the skin, showing increased circulation there, but the person probably sees faint luminous flashes, or sparks; and this, if not too far prolonged, is followed by an increased functional capability of the whole eye. These sparks should be so graduated in their *length* as to be bearable, and their succession not continued more than a minute at a time. If we employ electro-magnetism, the superficial portions of the eye respond to its effects, while the retina appears to be but very little reached by it; at least the author has never known the luminous flash or spark to be produced by it. If the magneto-electric currents are employed as strong as they can be borne, and with the switch of the machine set so as to give only

a one-way current, then, if the positive pole is placed over or near the eye, the retina is decidedly affected. If primary *galvanic* currents are directed to the eye or eyes, by placing the small moist sponge electrode over the closed eyelids, and thus *upon* the eyeball, then the moderate, constant, and steady current produces no other *sensible* effect than a slight prickling in the skin of the eyelids; but if now the current is interrupted, reversed, or varied in density, then there is produced a flash of light as often as the interruption, reversion, or other variation is repeated. This is no actual development of electric light, as might by some be supposed, but merely an instantaneous increased action of the retina. The third nerve, if involved in any lesion, arising as it does from above the bifurcation, ought to be affected on the same side; and so it is always found: the pupil on that side is dilated, and seen to be larger than the pupil on the unaffected side of the body. Besides, it is not necessary to apply the galvanic current to the eye at all in order to produce this luminous flash or spark; nor yet is it required that some branches of the *tri-geminal* should be embraced by the electrodes. Through the mysteries of reflex action, this phenomenon is frequently produced while operating with galvanic currents about the branches of the cervical ganglia in the neck, as also about the head while treating for crown headache, or for nervous deafness, or contractions of the occipital portions of the *trapezius*. Indeed, this was noticed long ago; for Dr. Achard, of Berlin, by actual experiment, found, "that if one pole of a considerable voltaic pile was placed in the mouth, and the other in the rectum, *there was seen a flash of lightning*" at every closure and opening of the chain.*

But if the wet sponge electrode is pressed upon the closed eyelid, while the other electrode is on the upper part of the spine, then at every sudden application, variation, or interruption of the active galvanic current, the flash will appear; and

* Versuche Uber die Gereizte Muskel und Nervenfacer, by Von Alexander Humboldt. Berlin, 1797, vol. i. p. 334.

the degree of this is in ratio with the intensity of the current employed, and inversely to the resistance, or failure of in-working. This flash evidently results from a direct electric excitement of the retina. If the *positive pole* is over the eye, the flash is purple or bluish; but if the negative pole is there, then the flash is a pale reddish yellow, or an orange-colored light is seen. These luminous flashes are the brightest at the circumference when the negative pole is to the eye, but the lightning flash is uniform when the positive pole is placed there.

*The Iris.* — If we direct one pole of a very moderate electro-magnetic or galvanic current to the most prominent portion of the cornea, while the other electrode is placed upon the face, the circular fibres of the iris are seen to contract, not slowly, but most promptly, much as do voluntary muscles; and when the current is opened, the contraction of the iris *as instantly* ceases. If the small sponge tipped ivory electrodes are now applied to the opposite edges of the cornea of one eye, or a little farther back on the sclerotica of the eye, then the *radiar* fibres of the iris are extended, as is an extensor muscle, and thus the pupil is enlarged. If these little electrodes are applied to the right and left of the eyeball, the pupil then assumes the form of an egg standing upon end; if the electrodes touch the eyeball above and below, then the oval pupil is horizontal. Thus we can act on the iris of the eye by the electric current so as to contract or dilate the pupil according as we direct the electrodes to the *sphincter pupillæ*, or to the *dilator pupillæ*. The pupil of the eye in man can thus be constricted simply by means of a single voltaic pair, as by my local silver battery, if the one metal is placed in the nostril, while the other is upon the tongue; and then — the patient sitting in the mildest light of the room, where there is only just light enough to see the oscillations of the pupil, — upon making and breaking contact between the two metals by the clasp of the insulated conductor, the pupil is seen to dilate and contract; or, rather, to contract with the contact, and to dilate with the breaking of the circuit.

1. The External Opening into the Ear at the bottom of the *Concha*.
2. The Meatus Auditorius Externus, or cartilaginous canal.
3. The Membrana Tympani, stretched upon its ring.
4. The Malleus.
5. The Stapes.
6. The Labyrinth, where is also the loop fringe of the Auditory Nerve.

Fig. 26. An Anterior View of the Left Ear, showing the External Ear, the Meatus Auditorius, the Labyrinth, &c.

2. *Hearing*. — The normal effects of electricity on the auditory nerve and organs of *hearing* are mostly those of increased noises, as roaring, scratching, and dropping, or of painfully exalted hearing and throbbing. But all these are greatly varied, according to the kind and method of electricity employed. The induction currents, as employed and advised by Dr. Duchenne, and so generally adopted by physicians as the electric remedy, are usually a failure. To fill the ear with water, and then maintain the point of the electrode, during the *seance*, deep in the water and near to the tympanum, and that without touching the sides of the canal, is easier advised than done; besides, the patient will tolerate only so slight a current, that the result is apt to be fruitless. For these reasons, the author has abandoned that method entirely. From long experience he finds the following a more practical and successful method for this operation in the ear: First, to put into the ear of the patient one or two drops of warmish water. If by accident more is dropped, turn the head over to that side and work it out. Then adjust one electrode low on the back of the neck, which may be the large, flat, moist sponge, while into the meatus of the ear is

introduced another tiny electrode, made for the purpose, of ivory, silver wire, and sponge, so as to insulate the wire excepting its ends. This ivory *ear electrode* is two inches in length, one quarter of an inch in diameter at the outer end, and then tapered down to one twelfth of an inch at the smaller end. This is perforated lengthwise, so as to take a double loop of fine silver wire, that seizes a bit of the finest sponge, which is drawn firmly into the little cupped end of the ivory tube, and then clipped into a ball-shaped tip, while the wires pass through the instrument and appear at its outer end, where they are secured and exposed convenient for contact. When this delicate instrument is carefully introduced into the ear, so that the moist sponge rests gently, and not painfully, against the moist membrane of the tympanum, and the patient is sitting in a reclining and easy posture, while the operator is seated behind him, then, whether employing primary or secondary, i. e., Faradaic, or Galvanic currents, the making and breaking of the circuit is done simply by applying the wire tip of the battery conductor to the silver projection of the ear electrode; and this will be found both practical for the physician and agreeable to the patient, and attended not unfrequently with success, even in the very same cases where the old method had been attempted in vain. In this manner, the patient can bear more current, while this is all the better concentrated upon the enfeebled or paralyzed auditory nerve and the minute muscles of the internal ear, so that the operation is left more to the judgment of the physician than to the sensations and requests of the patient. For these reasons, we are to proceed with the utmost caution. It should be borne in mind that the zinc or *negative pole* produces the greatest effects in the *ear*, while it is the silver or copper *positive pole* of the battery that exercises the greatest effects in the *eye*, *nose*, and *mouth*. The galvanic current makes a sound in the ear *when* the circuit is closed and *while* it remains closed, growing more and more intense until the circuit is opened. The induction currents cause the sound of a scratch; or, if prolonged, the sound is like the buzzing of a fly, or the distant steam-whistle. Dr. Ritter says the pitch of these sounds is that of G. Dr. Althaus says it

is that of A. The *intensity* of sound is as the intensity of the current and the state of the nerves, but the *pitch* is always the same. While treating the ear with electricity, and particularly if we employ galvanic currents, we may have, now and then, extra-polar workings, manifested by a metallic taste, or even by a flow of saliva if the current is strong or long continued, or if the nerves are in a state highly susceptible. By this unpurposed electro-physiological test, we ascertain that the *chorda tympani* is intimately connected with the sense of taste. This is corroborated by clinical experience; for in some cases of palsy of the *portio dura*, there is also loss of taste on the same side with the paralyzed muscles of the face, which also disappear together. The extra saliva that flows, and the inclination to deglutition during the action of the current upon the drum of the ear, probably proceed also from the chorda tympani, *or are the result of reflex action;* I am inclined to believe the latter.

The author would here remark, as the result of long and often repeated observations, and as an important item in the general prognosis of all nervous affections, that where the external ear of man, woman, or child, is seen to be *not well turned and full formed*, i. e., where the helix or external rim of the ear is decidedly deficient, particularly if with this the upper portion of the ear is *delicate*, *thin*, and *dwarfed*, or even where the whole ear is unusually small, crumpled, or deformed, wanting either in substance, posture, or well-developed outlines of plumpness and curves of beauty, — in such a person, the nervous system is also peculiar; *there is a great liability to some nervous affection.* My experience authorizes me to state, that in nearly seven cases out of every ten of all such persons so marked, there is already manifested some nervous derangement or confirmed nervous disease. According to my observations, there is the *coincidence* at least, that the nervous system of such individuals is either imperfectly developed or unduly developed, (in given parts so as to constitute unbalanced nerves,) for certainly such persons are peculiarly *prone* to pain, palsy, chorea, incurable hysteria, and hypochondria, or insanity; such like accidents appearing from no cause, or from the slightest causes. But what is still

more interesting to medical men, is the equally apparent fact, that when such patients are restored after the greatest vigilance and most persevering treatment, *they, of all cases, are the most liable to relapse*, and that from the least exposure.

The knowledge of this may be of value to many, because we may sometimes say to such persons or their friends, "*Beware;* do not over-tax or fret, but rather try to physically develop, for *here is a delicate nervous system.*" If the individual is already affected with some nervous derangement or disease, then our prognosis must be all the more guarded and prudent; but at the same time advising, if possible, such measures as will secure the attainment of *ordinary powers of endurance.*

3. *Smelling.*—The normal action of electricity on the organs of *smelling* is more that of a simple stimulus, or irritant, than a direct helper in the physiological function. The *Schneiderian membrane* receives the impression from electricity as if painfully scratched, but without any increased power for smelling. The *sentient nerves* prevail here, as they do upon the face, only more so. Dr. Ritter appears to have been the only one to experience in his own person, in this respect, the effects of a very strong electric current. He used a voltaic pile of twenty-five pairs, and the effect on him was terrible. He found the effects different according to the *direction* of the current. When the current was inverse, then, both at the commencement and while the circuit was closed, there was a sense of acidity, with a loss of the sneezing faculty; but at the cessation of this current, and for a short time after, he perceived an ammoniacal smell, with an *increased* capability for, and disposition to, sneezing. If the current was reversed, then the reversed results ensued, namely, ammoniacal smell and sneezing on *making* the current, and as long as it continued; then the acid taste, and loss of power to sneeze, occurred on breaking the circuit, and for a little time after.

It is probably familiar to all who use the friction machine that when the disruption discharge is allowed to take place without a spark, as from points, and hence without heat, the oxygen of the air is thus modified, and ozone is evolved. This is sensible to the smell like that of a phosphoric and sulphurous odor, or as

something in the atmosphere; but this does not affect the state or action of the olfactory organs. The fact is, the author has almost nothing, from his own experience, to state under this head; but if he had positive occasion for the employment of this agent here, he would make the application rather to the external portions of the nose than to the nasal membrane, except in a paralysis, or such lost degree of sensibility that some few elements, at least, might be tolerated by the patient. The positive electrode to the interior of the nose has more effect than the negative.

4. *Tasting.* — The normal actions of electricity on the *mouth*, and organs of taste, are certainly as curious as useful. Galvanic currents are here very sensitively felt, producing a metallic, sour, or alkaline taste, twitchings of the tongue, increased flow of saliva, flashes of light, pain, prickle, and heat. Faradaic currents, if here moderately applied, produce only twitchings of the tongue. Frictional sparks act here more as do galvanic currents. It is supposed that these different phenomena are brought about by the action of electricity *through the gustatory nerve*, just as *sensations* of light are induced by it, when directed to the retina; or of sound, when directed to the auditory nerve.

5. *Sentient Nerves.* — Healthy skin nerves, which we know are the *nerves of sensation*, or sentient nerves, are observed by the aid of a microscope to be arranged in their peripheric terminations much like fine moss, or the pile of fine, uncut, silk velvet. If the direct action of a considerable galvanic current be brought to bear upon the skin, and thus *immediately* attack those nerves, there is produced a sensation of warmth, heat, or burning, with another sensation of together-drawing, pursing, or contraction, with a prickling or pain, — one or more, in proportion to the *strength* of the battery, to the *sensitiveness* of the skin, and to the *in-working* of the current. These sensations, or some of them, may continue as long as the circuit remains closed upon them, and that with a rapid increase in degree, until quite unbearable. If, then, the action of this current be still maintained for a long time, i. e., like an overdose or abusive use of a powerful medicine, then there is produced a *diminution* of

these sensations. Indeed, if it should be still longer continued, and a still stronger current be employed, there could be produced a sensation of numbness, and perhaps of coldness, which remains a few minutes after the current is removed. Then the physiological sensations soon return again, however, with a somewhat increase of function.

If electro-magnetic currents are thus brought to bear upon these nerves through the skin, then sensations are produced which vary according to the *intensity* of the current, the *rapidity* with which it intermits, and the *sensitiveness* of the skin. The sensations are different, also, on different parts of the body and limbs. They may be extremely pleasant, or as extremely disagreeable, or even intolerably painful; or there may be a together-drawing, contracting, pinching, pursing, prickling, or, as sometimes experienced, a burning sensation. These cease when the current is opened. An induction current of the same quantity and intensity has a greater effect upon the sentient nerves, in proportion to the frequency of the interruptions of the current, *up to a certain degree*, which, for instance, may be about all the nerves can bear; but if the vibrator is screwed up a trifle, so as to make the interruptions extremely fine and rapid, then the current is more easily borne, and not only so, but it then becomes almost or quite pleasant, particularly if it is being applied to the back or shoulders. But I believe there is in this case more indirect effect; i. e., *reflex action*, because this current more nearly resembles the continuous galvanic current. A pretty rapidly interrupted current has more effect on the sentient nerves than very slowly interrupted currents, because *it is the law of their action to feel or retain the effects of an impression for some little but appreciable time, after being acted upon.* So where a sentient nerve, that is in health, is subjected to the action of a single blow of an induction current, if of low tension, there is almost no sensation; but if these blows or shocks are then *repeated* faster and faster, the sensations will likewise increase, because the sentient nerve is not now in its normal state, i. e., when it receives the second, and third, and succeeding shocks, but is in an excited condition, or polarized. Thus it is easy to

understand why the sensations produced by the induction currents increase in proportion to the velocity of the interruptions, to a certain degree. So much for the *immediate* sensations. Generally speaking, if the continuous, smooth, or even action of a moderate Galvanic or Faradaic current be directed through a *sentient nerve*, in a *direct* or down-running direction, then there is produced a quieting, diminishing, or *down-toning* effect. If, on the contrary, the current be directed so as to flow through the sentient nerve in an *inverse* or up-running direction, then there is produced an *increased, exalted*, or *toning-up* effect; that is, in the former case there is produced *diminished sensation;* in the latter case, there is produced *increased sensation.* This rule is even still more marked, when these currents act upon sentient nerves that are sick and morbidly increased in their sensibility, as in cases of true local neuralgia. But these valuable "*general principles*" are still further influenced by the kind of *electrodes* that are used in the trials, and by the *method* of managing them and the current. For *quieting these nerves*, we should always choose broad, soft, warmish and moist electrodes, as fine and soft sponges, which are to be gently applied to the skin, within a few inches of each other, and kept in gentle but ceaseless motion, with a careful and gradual letting on of the current, and as gentle and gradual taking it off, after an application of a minute or less. This may be repeated, after a recess of a few seconds, for some half a dozen times, at the same *seance*. If not successful, these seances, or sittings, may be repeated every few hours. But for cases of anæsthesia, and wherever we wish to arouse and *wake up* sensation, then not only must the current be *inverse* in direction, but it may be interrupted, or reversed, or alternated, from second to second, and that through *small*, say one inch ball, *electrodes*, covered with wet *wash-leather*. The current, here, too, should be strong, and it must be let on, reversed, and interrupted *suddenly*, but not continued more than a minute at a time. One electrode may be placed *over the nerve-trunk, while the other is moving over the palsied periphery, or border points of the palsied muscles.*

According to the laws of Marianini, as they relate to the phys-

iological effects of electric currents on the *sentient nerves*, we gather the conclusion, that the sensations caused by the application of the continuous current of electricity are strongest on *closing* the *inverse* current, and on *opening* the *direct* current; but the contrary takes place when the *motor nerves* are acted upon; for muscular contractions are more readily produced on *closing the direct*, and on *opening the inverse*, current; for this reason, therefore, if mixed nerves are electrized, we obtain the following

*Effects on the Mixed Nerves.* —

Direct current. { Closing the circuit — Contraction. / Opening the circuit — Sensation.

Inverse current. { Closing the circuit — Sensation. / Opening the circuit — Contraction.

When we electrize mixed nerves, the phenomenon that results is due to the peculiar excitation of the filaments of both sentient and motor nerves of which they are mutually composed, and hence, to a greater or less degree, to *reflex action*. But the *direction* of the current mainly determines the *physiologic* and the *therapeutic* result. Hence, this rule is held to be the fundamental, viz.: *that the direct current can produce powerful muscular contractions with comparatively little sensation, or pain; while the inverse current can produce greater sensation, or pain, and that with greater "reflex action;" while the muscular contraction is comparatively weak, or even totally wanting; also, that the reversing the direction of a current from second to second, increases its exciting, reflex, and constitutional effects.*

According to the *law* first laid down by Dubois-Reymond, it is moreover perfectly easy to understand the action of electro-magnetism, and other *induction* currents upon the motor nerves and muscles. The physiological action is in this case the greatest possible for the given amount of electricity, as to quantity or intensity, that actually courses through the nerves. These currents are necessarily made up of the least conceivable *bits* of currents, which are instantaneous, succeeding each other with the greatest rapidity, in consequence of the make and break in the inducing current of the battery, or of the approach and leaving of the magnet, &c. But, I ask, must it necessarily fol-

low that the current that produces the greatest possible effects, *as manifested by contractions*, must therefore *always* be *the most remedial* in effect? I think not; although, in fact, it may yet be proved to be so. Where the action of the current is indicated for exercising the deep muscles, such as cannot be done by passive motions, nor yet by any kind of mechanical manœuvres, these currents act admirably. But where there is required a catalytical action in the molecular structure of the tissues and blood, and for reëstablishing the dominion of volition, or, as we call it, the *will*, then, if not contra-indicated, the galvanic currents not only seem, but prove to be more powerfully restorative. Notwithstanding, we must bear in mind that it is the opinion of Dr. Duchenne and many other experienced medical electricians in Europe, "that *induced* electricity is essentially medical electricity."

There can be summed up the following *rules:* If the electric current be directed through a motor *nerve*, then will the whole deep substance of all the muscles, which are animated by ramifications of that nerve, enter into contraction. But if the current be applied directly *to the muscle*, then *only* those fibres are seen to contract, which are nearest the electrode, and traversed by the current.

### *Effects of the Electric Currents on the Motor Nerves.*

*If a galvanic current is directed through a motor nerve of the recently-killed animal, contractions of all the muscles that are ramified by this nerve are produced on closing as well as on opening the circuit; and that, too, whether the current be down-running* (direct), *or up-running* (inverse). Now, this will fail to be done, if one electrode is applied, say to the right of the nerve trunk, while the other is to the left of it; for in this case the current will pass transversely across the nerve. Therefore we must be particular to place the electrodes *over two points of the nerve;* or the one over the *nerve*, while the other is on the *depending muscle;* in either case, the one is to be so situated above the other, that the electric current will traverse the nerve

in a longitudinal direction; or, better still, if in a somewhat *oblique and longitudinal course*, so as to thus embrace the greatest possible number of nerve filaments, although the position of the electrodes on the skin may be close together.

Muscular contractions in the living human organism cannot be produced from the excitation of pure motor nerves by an electric current, *unless* those nerves are in some little degree or sense possessed of their normal integrity. True it is, that the electric stimulus is capable of so disturbing the molecular equilibrium of the motor nerves and their depending muscles, as to produce the state in which they are physiologically active; and this disturbance, if judiciously made, does not cause any injury to nerve, muscle, or central organ, but rather tends to *reëstablish* the lost or impaired vital functions of the reciprocal actions of nerve, muscle, and central organ, whenever so lost, provided they are under the above conditions. Dr. Bernard has shown that if a motor nerve is galvanized, while in its normal physiological condition, — i. e., while it is still connected with the spinal cord of the living animal, then a contraction is produced *only* on *closing* the circuit, be the direction of the current either direct or inverse. But if the nerve is some *fatigued* by energetic or very prolonged action, by heat, or by any other means, then *two* contractions are produced by either current, the one at the closing of the circuit, and the other at its opening. Therefore, if this phenomenon is observed in practice, we calculate that the nerve is *fatigued;* i. e., it is in a degree exhausted. Then, again, if the fatigue is greater still, the contractions are only observed on closing the direct, and opening the inverse, current. If the fatigue is still greater, we obtain only a single contraction, and that only on closing the direct current. Then, if the fatigue is even greater still, and the exhaustion is *total*, — i. e., complete and final, — there is no more contraction produced under any circumstances whatever. *This is strictly peculiar to the nerves of living human beings.*

Again, we have already shown, that during the time a continuous, moderate, and even-flowing galvanic current is traversing a motor nerve, *no visible contractions occur*, although a real

catalytical and polarizing effect *is as certainly in progress*. But the visible physiological effects that are manifested by contraction, occur rather at the moment when the density of the current suddenly rises from *zero* to a certain height, as is the case on establishing the circuit, and also when the density of the current descends again from a certain height to zero, as occurs on breaking the circuit. Setting out with these facts, Dr. Dubois-Reymond gives us a great *electro-physiological law* for the motor nerves in the following terms: "The motor nerve is not excited by the *absolute amount* of the density of the current of electricity, but merely by the variations which occur in the density of that current from one instant to the other; and the physiological effect is the greater, the more considerable are the variations of the density of the current; that is, in proportion as the variations take place less or more rapidly, or as they are more considerable in a given space of time." *

But we can say still further, that it is *not* absolutely necessary to actually *break* the current that is traversing a nerve in order to produce contractions; for these physiological effects are brought about even by the minor variations in the density of the electric current, as is shown by moving one of the electrodes a little farther from the other while the current is flowing, and while both electrodes remain on the skin; or by now pressing the electrode more or less; or it can also be done by increasing the current from switching on other series of cups through the key-board, or by quickly taking a portion away, or by diverting a portion of the current. But this power will be shown still more, if the direction of the current is *suddenly reversed* every second, as by the *current turner* of the key-board, although the current is constantly flowing; besides, this latter effect is observed to be more and more powerful, for a time at least, until the nerve is over-fatigued, or exhausted, when it will be observed to diminish; but that diminishing I do not call paralyzing *in any sense of the word*, more than hard work is paralyzing; unless they are carried to great extremes as to

* Untersuchunger uber thieristhe Elektricitat, Berlin, 1848, vol. i. p. 258.

power, and length of time continued, &c. Either work, or Galvanism, and Faradaism, may be injurious, when thus made empirical and abusive. *Feeble muscles and limbs can be rubbed by strong hands, until they are powerless.* Joints that are stiffened and weak may be readily over-exercised, so as to be more helpless than before. I have seen cases of "wasting palsy" brought to my rooms that had been "*so faithfully*" and perseveringly shampooed with some prescribed liniments, or with coarse, wet towels, and that, too, by the advice of the medical attendant, performed perhaps by the devoted mother from the highest motives of love and duty, — so overtaxed *by these means*, — that the process of atrophy and degeneration had gone on with most shocking and astonishing rapidity, and to a degree altogether incredible unless observed.

For these reasons, the author is all the more inclined to interpret the *over-long*-continued action of a medium faradaic or galvanic current, either on a motor, sentient, or mixed nerve, in the first instance, *as pre-occcupying* or *diverting the normal nerve action*, and which is sooner or later followed also by a fatigue, and then an exhaustion that is speedy in proportion to the strength of the electric current, and the endowment of the nerve; much the same as is produced by very violent, unremitting, and protracted labor; only the electric current's effects are quicker and more complete than labor's effects in producing this class of results, and can act where labor cannot be brought to bear.

### *Effects of Electric Currents on the Sympathetic Nerves.*

The earliest experimental researches on the ganglionic or sympathetic nerves we find recorded, were undertaken in 1727, by Dr. Pourfour, who found that from the section of the cervical filament of the sympathetic nerve, the following phenomena are observed; a contraction of the pupil of the eye; a flattening of the cornea; a redness and sometimes injection of the conjunctiva; the secretion of the palpebral mucus is increased; the eyelids are partially closed, and the third eyelid, as in birds,

is large; the *nectitant membrane* becomes prominent and advances upon the eyeball. If the animal then continues to live a certain time after the operation, the eye becomes smaller and in effect shrunken, and drawn back in its orbit. These experiments were repeated and confirmed by Dr. Pupuy, Dr. Breschet, and Dr. John Reid. But more recently it is discovered, that if the pupil has become constricted after the section of the cervical sympathetic nerve, it can again be dilated if the cephalic end of the nerve be electrized.

In the year 1852, Professor Claude Bernard published his most interesting and valuable researches on the physiological offices of the great sympathetic nerve. He goes on to say, that after the section of the nerve, or after the destruction of the superior cervical ganglion, besides the phenomena long before noticed by M. Pourfour-du-Petit, the following are produced: a less or greater constriction of the nostril, and of the mouth, on the same side; an increase in the circulation of the blood, with an augmentation of heat and sensibility in the head. He observes, also, that if the cephalic (upper) end of the cut ganglionic nerve be electrized, then all these phenomena observed after, and in consequence of the section of the nerve, will equally disappear, and can even be exaggerated in the extreme. Not only does the constriction of the iris, that is produced by cutting the sympathetic nerve, disappear from being electrized, but the pupil becomes even larger than normal; the eye is plumper and more prominent; the temperature, which had been exalted, is diminished to a healthy standard; the nostril and ear of the animal, which had been red and injected, become quite pale again; but as soon as the electric influence is removed, then all the phenomena that first attended the section of the nerve, gradually reappear. But they can be made to disappear, again and again, by the repeated applications of the electric current to the nerve above the cut. Besides, if we apply a drop of ammonia to the conjunctiva of a dog, in which the section of this ganglionic nerve has been made, the pain will oblige the animal to keep the eyelids strongly closed; and then, if the cephalic end of the cut nerve be electrized, he will immediately open his

1. The Plexus on the Carotid Artery, in the Carotid Foramen.
2. Sixth Nerve. (Motor Externus.)
3. First Branch of the Fifth, called the Ophthalmic Branch.
4. A Branch on the Septum Narium going to the Incisive Foramen.
5. The Recurrent Branch, or Vidian Nerve, dividing into the Carotid, and the Petrosal Branches.
6. The Posterior Palatine Branches.
7. Lingual Nerve joined by the Chorda Tympani.
8. Seventh Pair, also called the Portio Dura, or Facial Nerve.
9. The Superior Cervical Ganglion.
10. The Middle Cervical Ganglion.
11. The Inferior Cervical Ganglion.
12. The Roots of the Great Splanchnic (sympathetic) Nerve arising from the Dorsal Ganglia.
13. The Lesser Splanchnic Nerve.
14. The Renal Plexus.
15. The *Solar Plexus.*
16. The Mesenteric Plexus.
17. The Lumbar Ganglia.
18. The Sacral Ganglia.
19. The Vesicle Plexus.
20. The Rectal Plexus.
21. The Lumbar Plexus, (Cerebro-Spinal.)
22. To the Rectum.
23. To the Bladder.
24. The Pubis.
25. The Crest of the Ilium.
26. The Kidney.
27. The Aorta.
28. The Diaphragm.
29. The Heart.
30. The Larynx.
31. The Sub-Maxillary Gland.
32. The Incisor Teeth.
33. The Nasal Septum.
34. The Globe of the Eye.
35, 36. The Cavity of the Cranium.

Fig. 27. A View of the Great Sympathetic Nerve, also called the "Ganglionic System of Nerves," and showing the relative position, as also the communication, of several other nerves.

eyes again, notwithstanding the pain he is all the while experiencing; nor indeed is he able to shut them, for they are kept open as long as the current traverses the nerve, while the redness caused by the ammonia also diminishes, and soon entirely disappears.

*Experiments on the Sympathetic Nerve.*—By a section of the cervical ganglionic nerve, nearly all the *muscles* of the eye and of the angles of the mouth, and of the nostril, become permanently contracted. The ear of the animal is held erect; the quantity of blood, not only in the ear, but in that whole side of the head, is decidedly increased; the arteries are fuller and beat with more force; the temperature is increased for a length of time; the current proper of the muscles is stronger; poisons and other substances which are deposited in equal quantities on the two sides of the head,—i. e., under the sub-cutaneous cellular tissue of the face, or at the base of the ears,—are found to be *more rapidly absorbed on that side where the section of the nerve had been made;* but *chloroform destroys the sensibility there much slower* than on the sound side; the *rigor mortis* appears *later*, and lasts longer; putrefaction begins later.

It is found also, that nearly all the phenomena observed as the consequence of severing the cervical sympathetic, may be produced by any means whatever that will simply increase the amount of blood circulating in the blood vessels of the head in a given time; as by holding the animal up by its hinder legs, which produces a strong congestion of the head, and contraction of the iris, &c. Hence we infer, that all, or nearly all, these phenomena are due to the deranged condition of the blood vessels, brought about by the division of the cervical nerve, thus enlarging their calibre and allowing more blood to pass through these vessels in a given time. When the entire *cervical sympathetic* nerve is electrized actively, i. e., *severely*, we find the following results: An opening of the eyelids; a dryness of the cornea and conjunctiva; a dilatation of the pupil; a contraction of the blood vessels of the whole eye, and consequent diminution in the quantity of blood there; a decrease of temperature and of sensibility; the nervo-electric current proper of

the muscles of the eye is less; the excitability of the motor and sentient nerves of the iris, as also of the muscles, together with the contractility of the arteries, disappears sooner, after death, than on the other side; the cadaverous rigidity and putrefaction commence sooner than on the sound side, because of the greater electrolytical or chemical changes produced by the powerful and prolonged action of the current on the nerve and tissues.

M. Bernard says, if the external auricular nerve, which takes its rise from the cervical plexus, and transmits the reflex action from the external ear to the spinal cord, and thence to the great sympathetic, be cut across, the increased temperature of the external ear that is thus produced cannot be lowered to its natural standard again by the direct means of induction currents to the lobes of the ear; while if the application be made rather to the cut cerebral end of the sympathetic branch, then the temperature immediately decreases to its normal standard. On the other hand, if no section of the cervical sympathetic nerve has been made, and the external ear is sharply Faradaized, then the temperature of the whole auricle is diminished.

It follows, therefore, that if we electrize the external ear, as by direct Faradaization applied to the upper or lower part of it, there is produced a different phenomenon, according as the section of the superior cervical sympathetic *has* been made or has not been made. Where the section of this nerve has been made, the ear becomes hot, &c. Then, if electro-magnetism be applied so as not to pass through the thin diameter of the auricle or external ear, but rather so as to traverse its *longest extent*, as from top to bottom, the temperature becomes thereby *increased;* but if the electricity is directed rather to the cephalic cut end of the sympathetic nerve on that side, the temperature is *diminished.* But this has been further illustrated by test. Dr. Bernard electrized the long and delicate ears of a rabbit, in one of which he had already cut the left sympathetic nerve; while the other, on the right side, was left intact. Now, when the left ear was electrized, a rapidly-increased heat was noticed; but when the right ear was electrized, as rapid a diminution of heat was produced. He explains this thus: the elevation of tempera-

ture on the side where the nerve had been cut results from the circumstance that, under the influence of the *pain*, the heart acts more vigorously upon the arteries of the ear, which are already relaxed in consequence of the section of the ganglionic filament; while on the right side, where the nerve has not been cut, the electricity causes an excitation of the sentient nerves, which impression is transmitted to the spinal cord, and then again by a *reflex* to the sympathetic; hence the vessels of the ear are constricted, and therefore the action of the heart cannot produce the same results as it does on the other side, where no reflex action from the spinal cord to the sympathetic ganglia is possible.

Professor Weber discovered, in 1846, that where the *inferior* cervical ganglia of the sympathetic is electrized by an active induction current, the pulsations of the heart are greatly *increased*. The same phenomenon occurs, if the cardiac branches from this ganglia are subjected to the action of the current. But if the *vagi* are electrized the action of the heart is *diminished*. If the current be stronger, or longer used, the heart's action comes to a stand-still. Therefore the vagi is a monitor-nerve.

Dr. Brown-Sequard maintains, on the contrary, that the par vagum is the true vaso-motor nerve of the coronary arteries, and that its irritation should cause contraction of the vessels, and thus, by retarding the passage of the blood into the cardiac tissue, diminishes the frequency of, and eventually suspends, the heart's action; while, on the other hand, their *section*, by allowing the coronary arteries to become over-distended with blood, excites the heart to preternatural pulsations.

Professor Pflueger discovered, in 1856, that the splanchnic nerves exercise a similar controlling influence over the peristaltic movements of the intestines, much, indeed, as the vagi do over the contractions of the heart.* He found that when the electric current is applied to the splanchnic nerves, which take their rise from the six lower dorsal ganglia of the sympathetic, then the vermicular movements of the small intestines are very soon sus-

* Uber das Hemmungs-Nervensysten fur die peristaltischen Bewegungen der Gedarme, Berlin, 1856.

**1, 1.** A line drawn from the highest point of one Ilium to the other, horizontally.

**2, 2.** A line drawn perpendicularly from the Anterior Superior Spinous Process to the Cartilage of the Ribs, just under the Nipple.

**3, 3.** A line similarly drawn on the opposite side.

**4, 4.** A line drawn transversely to these, (but parallel to the line marked 1, 1,) touching the most prominent parts of the Costal Cartilages, thus forming the *technical* Nine Regions.

***5, 5.*** The Right and Left Hypochondriac Regions.

**6.** The Epigastric Region.

**7.** The Umbilical Region.

**8, 8.** The Right and Left Lumbar Regions.

**9.** The Hypogastric Region.

**10, 10.** The Right and Left Iliac Regions.

**11.** The lower part of the Hypogastric, sometimes called Pubic.

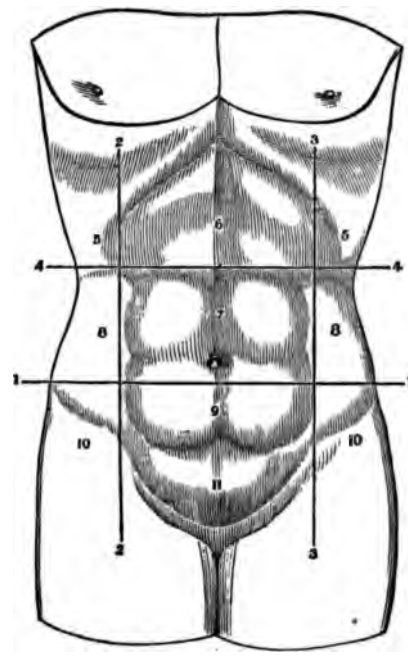



**Fig. 28.** A View of the "Regions" of the Body.

pended. From this he inferred that there is a peculiar set of nerves for the *physiological action of diminishing*, or even suspending, the various movements of the intestines, and he designated them as the "*inhibitory system*" of nerves. But Mr. Lister has more recently found that the inhibiting effect through these nerves is produced only when the strongest currents are directed to the roots of the splanchnic nerves; *while, on the contrary, if more moderate currents are employed, there are observed accelerated peristaltic motions.**

*Inhibitory* nerve-action is a term adopted by a class of physiologists to express a certain restraining, controlling, or *regulating* nervous influence over organic functions. This doctrine, originated by Pfluger, is indorsed by C. Hanfield Jones, and corroborated by various experimenters. I conceive it to be synonymous with "*reflex nervous action*," as taught by Brown-Sequard; while Lister teaches that "the same afferent nerve may, as it is operating mildly or energetically, either exalt or depress the functions of the nerve-centre on which it acts." In answer to this, Dr. Jones says, "It is not the energetic operation of an afferent nerve that causes inhibitory action, but its being *injuriously* affected by some impression made upon it. The enfeebled state of the nerve itself, or the centre to which it proceeds, or the severity or the malignity of the impression, may give rise to the familiar effect." To confirm this, he reminds us that Wilson Philip long ago proved that sudden crushing of the brain, or quick destruction of the spinal cord, arrests the arterial circulation more abruptly than does excision of the heart. More recently, Claude Bernard has shown, that irritation of the posterior roots of spinal nerves suddenly checks the cardiac motions for a time, while irritation of the anterior roots has no such effect. To illustrate these propositions, a wide variety of cases is introduced. Now, in all such cases, it is no haphazard, nor yet a special functional relation, *but the extreme violence or morbid character of the disturbing cause*, that explains the mysterious inhibition, or reflex action. We may con-

* Preliminary Proceedings of the Royal Society, London, Vol. IX., No. 32.

clude, therefore, that reflex paralysis, or the inhibitory effect, is caused by a morbid impression upon a nerve-centre, that is probably already the weakest and most impressible, diminishing or exhausting its functional capacity as a neural agent, and that these terms merely indicate diversity of theories, but no difference in the facts.

There naturally grows out of the foregoing propositions the following: Dr. Brown-Sequard asserts that "the effects of excitation of the vaso-motor nerves consist, essentially, in a contraction of blood-vessels, which is followed by a diminution of the quantity of blood, diminution in the temperature, and diminution in the activity of nutrition; that the effect of interruption of continuity of the vaso-motor nerves (i. e., their paralysis) consists essentially in a paralytic dilatation of blood-vessels, which is followed by a greater afflux of blood, an increase of temperature, and a greater activity of nutrition." In short, he regards reflex paralysis as produced by anæmia of a nerve-centre, due to contraction of the blood-vessels supplying it, this contraction having its origin in a morbid *peripheral* nervous irritation. Reflex secretion, and other reflex normal functions, must be the result of a sufficient peripheral nervous stimulation.

Wharton Jones, Dubois-Reymond, and Becquerel have shown that even under direct excitation by electricity, or other stimuli, the *vessels* are found, after a temporary contraction, to dilate either to or beyond their normal caliber. Claude Bernard supposes that the *capillaries* may have two properties, one of contraction and the other of dilatation, and that the first of these is put into play through one set of nerves, and the other by another set. Then, again, Draper supposes that nervous excitation, sometimes, instead of producing fixed contraction, by acting upon the walls of the vessels, may pass them altogether, and act upon the nutritive changes in the tissues, so as to alter and increase these changes, and thus draw more blood into the arteries by the altered *suction power of the capillaries*. He thus based the theory of the normal attraction of the living

tissues for arterial blood. In viewing the same facts from all these stand-points, we are led to revert to the days of Haller and Muzer. The latter taught that "the contractility of the arteries is under normal excitation, as rhythmatic as that of the heart, and that only abnormal irritation produces tonic contractions of the vessels, seldom or never permanent; while paralysis of the arteries, inducing their passive dilatation, and blood-accumulation, may follow," either from the section of vaso-motor nerves, as in Bernard's division of the cervical-sympathetic, or from an exhaustive or suppressive disturbance of vaso-motor nerve-centres. We are led, therefore, to conclude, with Brown-Sequard, that it is possible to so blight or utterly exhaust the power of a nerve-centre, that the alteration of nutrition, which this temporary anæmia causes, may give rise to a *continued disturbance of nutrition*, which is now already under way, and allowed, by diminished control; so that, however slight, it would occasion grave results when once existing in a nerve-centre.

That each *ganglion* is an organ controlling certain functions in a definite locality within the body, is the opinion of some of our more recent and most able physiologists.* The sympathetic nervous system, in a general view, may be described as arranged in two principal divisions. The *first* may be considered to include the ganglia seated on or close to the cerebral and spinal, with the filaments issuing from them. The *second* division comprises the ganglia on the two main branches of the sympathetic, and on the branches in the visceral cavities. To the first division belong the ophthalmic, otic, and sub-maxillary ganglia on the glosso-pharyngeal and pneumo-gastric nerves, and on the posterior roots of all the spinal nerves; for, from all these, fibres appear to originate, which, in structure, resemble those derived from the proper ganglia of the sympathetic, and are distributed to the same parts. To the second division belong the ganglia arranged in a continuous line along the sides of the vertebræ, with their connecting cords, which make up what have been usually called the trunks of the sympathetic nerve, and all the ganglia placed

* Kirkes and Paget, Physiology, p. 366.

irregularly on the branches of the sympathetic, distributed to the viscera.

The ganglia seated upon the fifth, and upon the glosso-pharyngeal and pneumo-gastric nerves, together with the carotid plexuses, and their derivations, supply the meninges of the *brain*, and that viscus itself. The ophthalmic ganglion distributes nerves to the globe of the *eye*, the *otic* to the *tympanum*. The sub-maxillary ganglion supplies with nerves the side of the *tongue*, the sub-maxillary gland, and Wharton's duct. The spheno-palatine, or Michel's ganglia, supply with nerves of distribution the mucous surface lining the *nasal* passages, and partially all the mucous surfaces lining the passages within the cervical region. The six upper dorsal ganglia distribute nerves to the *aorta*, *œsophagus*, and *lungs*. From the sixth, seventh, eighth, ninth, and tenth thoracic ganglia the great splanchnic nerves originate, which terminate in the semilunar ganglion. The superficial and deep cardiac plexuses, together with the ganglionic tissue found in its own substance, distribute nerves to the *heart*. The last thoracic ganglia, through the third splanchnic nerves, and in common with the renal plexuses, distribute nerves to the *kidneys*. The lower lumbar ganglia, in common with the termination of the aortic plexuses, forming the hypogastric plexuses, distribute nerves to the *rectum*.

The spinal nerves supply the muscles of the striated variety, which are found in great proportion near the periphery of the body, in close proximity to the cutaneous system. Hence those nerves of the sympathetic system that join the cerebro-spinal system, which supply the voluntary muscles, would most probably be the ones that would supply those muscles and the tissues eccentric to them. From the ganglia seated upon the posterior roots of the spinal nerves, and from the sympathetic trunks upon each side of the spine, those nerves probably arise that *control* the organic functions in the cutaneous system and muscular tissue of the striated variety. Quite a proportion of the nerves that arise from the spinal ganglia pass into the posterior roots of the spinal nerves, and are distributed with them. Some of

the fibres derived from the great sympathetic trunks go direct to the viscera, while others pass through the branches of communication that connect them with the anterior branches of the spinal nerves, and joining those spinal nerves, proceed with them to their respective regions of distribution.

### *Effects of Electricity on the Intestines, Uterus, and Secreting Organs.*

Dr. Aldini observed, a long time ago, from actual trials, that the alimentary canal responds very remarkably to the voltaic current. Professor Achard, of Berlin, made the trial upon himself, and he testifies to the prompt and effectual action of electricity upon the functions of the bowels. It is an every-day occurrence to hear some patient testify to an unaccountable promptness of the movements of the bowels while taking treatments that require daily applications of Faradaic or Galvanic currents along the spine. As confident am I that the relaxed, inflated, and atonic *stomach* contracts, both in its longitudinal and transverse diameter when the electrodes are moved carefully from position to position, so as to include the stomach between them, in different directions, and so that the current passes through it, or, at least, so that its neighboring sentient nerves may bring about a reflex action on the viscus that *tones it up*. When examined under the action of the current in a mutilated animal, the movements of the stomach are invariably seen to be from the cardia to the pylorus — i. e., downwards.

If we directly Faradaize the *salivary glands*, we do not obtain a flow of saliva. Professor Claude Bernard has demonstrated* that if we Faradaize the *lingual* and the *auriculo-temporal* nerves, the *chorda tympani*, and the posterior parotid branches of the *facial* nerve, then there is an abundant flow of saliva. This he explains as being the result of the enlarged blood vessels produced by the electricity; that this dilatation of the vessels is

* Journal de la Physiologie de l'Homme, Paris, 1858, p. 649.

due to the attraction of greater quantities of arterial blood, that is always induced by the action of the current; and that the excretion of the saliva is effected by the same forces which attract the blood to the glands, and not by the tissue of the glands themselves, since the elementary substance of the salivary glands has no inherent contractile power. But if the above nerves are excited, according to Professor Bernard, the amount of saliva which may be gathered in a very little time from the salivary glands will be found to far exceed the volume of the entire glands themselves, so that it cannot be shown that the saliva is simply squeezed out of the gland. It is thus proved that the secretion occurs in the salivary glands at the very moment when the electric current is made to traverse these nerves of secretion. If the sympathetic nerve is traversed by the current, neither the normal nor abnormal secretion is then induced, but, on the contrary, all salivary secretion is arrested.

When the abdomen of a recently-killed animal is quickly opened and exposed to the air, particularly if a cool air is blowing over it, the small intestines are seen to contract, dilate, and move, from the contact with the air. But very soon these contractions cease. If, now, the poles of an electro-magnetic current be brought in contact with any portion of the intestines, — say on the ilium, — they will renew the contractions, and urge the contents of the canal towards their receptacle, the rectum. But observe: if the electrodes are applied near each other, — say on some portion of the duodenum, and retained there for a minute, and are then very quickly withdrawn from it, — the contraction that has been thus induced at that place continues, and *increasing* for a little time after the electrodes are removed, then moderately disappearing. The stomach is more quickly and strongly responsive to the electric stimulus than the duodenum. This latter is rather more so than the small intestines, and they are more so than the colon and rectum. But the *sphincter-ani* is more prompt and powerful in its response than any portion of the alimentary canal, while the *cæcum* appears to be the least so. The *ductus choledochus* and the liver contract notably under the influence of the electric current. If the elec-

trodes are applied on either side of the gall bladder of a mutilated living animal, it is seen to contract slowly but extremely, so much so that the contraction actually divides the gall bladder into two sacs or compartments, that are complete, while the great portion of the bile is quickly expelled into the duodenum. But whether the *pancreas* and *spleen* contract in the human organism, under this influence, is not so clearly determined; for while the earlier observers who employed constant voltaic currents, as Kölliker, Gerlach, and Dittrich, obtained negative evidence, Harless, Claude Bernard, and Wagner testify that they have seen contractions in the fibre-cells of these organs.

The *ureters*, the *urinary bladder*, the *uterus*, and *tunica vaginalis*, the *vas deferens*, and the *epididymis*, contract, some powerfully and others less so, but all more or less decidedly, under the electric current; and these contractions continue for a little time after the electrodes are removed. Dr. Weber early noticed at least partial contractions of the uterus in the living bitch, and other animals. But very recently we learn that Dr. Mackenzie, of England, read a paper before the Royal Medical and Chirurgical Society, showing his experience in the use of galvanism as to its action upon the contractile structure of the uterus, and its remedial powers in obstetric practice.* He first instituted some experiments upon the gravid uterus in the lower animals, the organ being exposed so that the exact influence of the electric current was seen. Thus it was shown that the electricity produced a peculiar and very remarkable influence upon the fibres of the uterus, and this was most notable when the electro-magnetic current was directed in a longitudinal direction — i. e., through the uterus from the upper portion of the spinal cord, the current running downwards, in a continuous manner, to the lower portions of the abdomen, or, better still, to the cervix uteri, or to the vulva. He found the local or direct application of both the electrodes to the uterus less effectual, even in that direction, and less still if applied transversely or obliquely; for in these two latter conditions, the contractions were local and partial,

* Braithewaite's Retrospect, Part XXXVII., p. 271.

being confined to a line directly between the placing on of the two poles. He found that single shocks produced no influence upon it. Guided by these results, Dr. Mackenzie has employed electric currents, in several very critical cases in obstetric practice, with remarkable success. See chapter IX.

*Effects of Electric Currents on the Heart and Blood Vessels.*

If we examine the heart of an animal immediately after death, as soon as the heart has ceased to beat, we see that the electro-magnetic current brings back the rhythmatic contractions. But the phenomena produced by applying the electric stimulus *directly* to the heart differ according to the part of the heart so touched. The contractions are uniformly more marked in the right than in the left ventricle; for after death, the left ventricle is usually found firmly contracted upon itself, and is more insensible to the stimulus. But the right ventricle is almost always surcharged with blood, and this contracts very beautifully when touched with the electrodes. If the animal is killed by chloroform, then sometimes the left ventricle is observed to be still continuing to pulsate a very little, while the right ventricle is entirely still, and largely distended with black blood. It is found that if the *right ventricle* be electrized in these cases, its contents are expelled, and its rhythmatic pulsations are soon restored.

It was ascertained long ago by Volta that respired air has lost a portion of its electricity, which must be absorbed by the blood, together with oxygen, in its return from the lungs. Hence it was contended, that one office of the function of respiration is to charge the blood *directly* with electricity from the atmosphere, as well as from the chemical changes taking place in the parenchyma of the lungs and air-tubes of the bronchia, to be conveyed to the left side of the heart, which it had lost on its return to the right, and that the proper stimulus to the respective cavities of this viscus is the same fluid in different states of electricity; and we well know that if venous blood fills the left side of the heart, its action presently ceases, the proper stimulus to the right side of the heart being none to the left.

Now, the two cavities being filled, at the same instant of time, with a fluid in different states of electricity, this matter, agreeably to known and fixed laws, will pass through the intervening muscular substances, directly from one to the other, and that not through the septum only, but the whole surface with which the blood is in contact. That is to say, entering at every point of the internal surface of the left cavity, from the positive blood with which it is filled, it will pass the whole circle of the fibres, and issuing in a similar way from every point of the opposite one to the negative fluid contained in it, a simultaneous contraction of both cavities of the heart is produced. This being effected, and a temporary equilibrium restored, the particles of the fibres which had coalesced during the transit of the electric fluid, will instantly resume a state of mutual repulsion, and the dilatation of both cavities be the immediate result, which, in this manner, will not consist in a mere flaccid relaxation, but in a powerful expansion of their walls, giving to the heart, as Dr. Carson supposes, the twofold action of propelling the blood by the force of contraction, and of drawing it back to itself by the vacuum produced by its expansion.

What makes this still more plausible, we may notice that in the action of the heart there is no confusion of pulsations, as first the contraction of one cavity, and then the dilatation of another, &c.; for, however irregular the action of the heart, as a whole, may be, the auricles first, and then the ventricles, always pulsate together in pairs simultaneously, and giving thus, by their double pulsation, the feel of one synchronous stroke. This view of the heart's action is supported by the fact, that there is no intermixture of muscle or nerve-fibres between the auricles and ventricles, and that by careful boiling they may be easily separated without laceration.

*Electricity of the Circulation of the Blood.* — M. Scoutellen has recently reported to the Academy of Sciences at Paris an account of some experiments upon horses which were previously made insensible to pain. He "found that the electric positive sign, indicating the direction of the current, was con-

stantly from the red or arterial to the black or venous blood." He concludes his memoir by saying that, "since it is demonstrated that the red blood and the black blood, in their contact through the walls of the vessels, which act as true porous vases, give stated electric reactions through the galvanometer, we must admit, that, as all the parts of our body are traversed by sanguineous fluids, there must necessarily be a constant disengagement of electricity in the most relaxed tissues of our bodies.

"Thus each organic molecule is incessantly stimulated by the animal electric fluid; and thus, under the influence of this excitement, all the functions of the body are performed. The oxygen contained in the red blood burns up the organic molecules with which it is in contact, and produces heat, without which life is impossible. Under the influence of electricity is effected, during digestion, the selection of the nutritive molecules and their assimilation. The same action takes place in respiration and in all the other functions. These facts perfectly agree with the electric phenomena of combustion. The carbon takes the negative electricity, and the surrounding air the positive; or, rather, the current is established between the carbon and the oxygen of the air. Now, the principal action of the red blood, by reason of the oxygen in it, is the producing of a true combustion in our tissues."

We said that different phenomena are observed from touching different points of the heart. If we are reminded, however, that the heart is animated with two peculiar sets of nerves, we at once comprehend the wide difference in the effects. The heart's nerves are, first, the *ganglionic*, and, second, the *vagi*. The ganglionic or sympathetic *is its motor*, and the *vagi is its regulator*. If the former is electrized, the contractions of the heart are *augmented;* if the latter is thus acted upon strongly, then the pulsations of the heart *stop*. Besides the above facts, first observed by Professor Weber, of Leipsic, there are very many other instructive results obtained from electrizing the *vagi*, which were, indeed, mostly discovered by M. Claude Bernard. He found,

by applying rather strong electro-magnetic currents to the two nerves vagi, on either side of the neck, that not only does the heart lessen its action, or totally cease action, but that respiration also stopped, and that the eyeballs were greatly protruded from their sockets. From this he inferred that there is at the same time an action of the *vagi*, both upwards and downwards; i. e., to the central organs, and to the viscera of the thorax. If the vagi be cut across and let alone, the actions of the heart rapidly increase, until they run wild, so that the number or frequency of the pulsations *cannot be counted*. We therefore know that the vagi is the *regulator*, and not the motor of the heart; and further, when very quick pulsations of the heart are occurring, we know that the vagi is paralyzed, or approaching a state of paralysis; or else the sympathetic nerve is conveying from the nerve centres some increased *abnormal* stimulus.

Faradaizing the nerves *vagi*, *actively*, *while intact*, we get the cessation of the heart's action, and also that of respiration; and the eyes greatly protrude. But if we cut the vagi across, as can be done in the living dog, and then apply the electric stimulus to the lower cut end of the nerve, it does not stop the respiratory motions, as might be expected, but it does effectually put a stop to the pulsations of the heart and arteries; and, moreover, it usually causes vomiting. But if the upper end of the cut nerve be electrized by the same current of electricity, no effect whatever is produced upon the movements of the heart, nor yet is the respiration disturbed, provided the current is a moderate one; *but if a stronger current be employed*, we then see that respiration is suspended, and that always during inspiration; that the blood in the carotid arteries becomes black; that there is a passive injection of a dark color, of the membranes of the mouth, throat, nose, and eyes, from the asphyxia; and yet the carotid arteries continue to pulsate. If this is not carried too far, and the electrizing is discontinued, the respiration is gradually restored, and finally their force and frequency become greater than before the electric stimulus was first applied. M. Bernard also found that, under these circumstances, the blood, the cerebro-spinal fluid, and the bile, all contained sugar; that the secretion

of urine is suspended, and at the same time there is an excessive flow of saliva. It is, therefore, fairly concluded, that the *vagi* do not form the motory system of the heart, but that they rather regulate the rhythmatic heart actions, which themselves are caused only by the sympathetic fibres. The aorta, large arteries and veins, and the smaller blood vessels are very differently affected by the electric current, and that in proportion to their structure and their attending nerves. Probably the aorta in man does not contract under its influence; but this is accounted for, when we recollect that the aorta is mostly made up of *elastic fibres*, while there are very few contractile fibre-cells. These latter are supposed to be so few, and so deficient in power, even when excited by electricity, that they are not able to overcome the elastic forces which constantly tend to retain the aorta open. This is true of man, but not so as regards the aorta of the horse, ox, or sheep; for here we find the aorta contains a very much larger proportion of the contractile fibre-cells than is found in the aorta of man. But in the human organism we find, again, that in the smaller blood vessels, and particularly in the smaller arteries, *the contractile fibre-cells largely predominate* in their structure; and this accounts for their strong contractions under the influence of the electric current. True to the *nature* of their contractile fibre-cells, they are moderate in beginning to contract, and that only after the action of the current for some appreciable time; and even sometimes after the electrodes are taken away are they seen to continue to increase their contractions to their maximum, and then as deliberately take on their normal state; which is so unlike the phenomena of electro-muscular contraction, on the one hand, and yet, on the other, as unlike the negative action of tissues that are composed simply of elastic fibres.

The action of electricity on the blood is mainly *chemical;* and therefore we might expect that *Galvanic* currents would have more effect than Faradaic, or than frictional electricity; and so it is. If we use galvanic electricity, we are able to coagulate fresh blood, taken either from an artery, vein, or capillary; and this can be done, moreover, where the blood is flowing in the vessels of the living body. If we act upon *arterial* blood by a

powerful current, a very firm clot is formed, which adheres to the walls of the artery, and so stops the circulation. This can be accomplished, in like manner, in the *veins*, but in less degree. If a current of moderate intensity is used, the clot forms in from five to fifteen minutes. The clot forms *only at the positive pole*, because of the decomposition of the salts of the blood, and the liberation of acid at that pole; while, at the *negative pole*, the action and decomposition there sets free an *alkali*, which renders the blood even more fluid than natural. "If the positive electrode of a moderately active galvanic battery is plunged into the artery of a living dog, the blood soon becomes coagulated, and that without pain, inflammation, or gangrene; but if the *negative* electrode is thrust into the artery, there is *no* coagulation, but rather the blood is rendered *more fluid*, with pain, inflammation, and sometimes speedy gangrene. Hence, whenever we wish to coagulate the blood in the vessels, as for varicose veins, or in an aneurismal sac, we must employ the *positive pole* in the sac or vessel, while the negative is simply a large moist surface contact, and so directed to the border of the sac, or vessel, that the current shall pass *directly* and *steadily through it*." (Becquerel.)

When galvanism is applied to blood vessels, they are found to contract pretty generally; but this appears to be much in proportion to the number of fibre-cells they respectively contain. Thus the aorta in man scarcely contracts under this influence, because it is mostly made up of elastic fibres, and with but very few contractile fibre-cells. But these fibre-cells are found far more uniform and abundant in the smaller arteries, and consequently *they* are seen to contract energetically, when thus influenced. They have a peculiarity of contraction, and that is, as repeatedly observed, only *after the current has been acting for a little time, and which effect also continues for a little time after the current is discontinued.*

Professor Claude Bernard assumes that the capillaries possess two properties,—the one for contraction, the other for dilatation,—and that either of these are brought into their physiological action under the influence of a peculiar set of nerves.

From most reliable researches, then, it is fairly demonstrated, that *the circulation of the blood through the smaller vessels and capillaries can be controlled by moderate electric currents artificially applied;* and hence the very natural inference, that the ordinary native or animal electric currents, which always exist in the living and healthy human body, are as constantly influencing the circulation of the blood. By such means the blood circulation may be deranged; so also may the various secretions *from the blood* be influenced. The diseases, alterations, or deviations of the blood are arranged by Dr. Simon in four classes, viz.: —

The first is where the fat and fibrine are increased, while the corpuscules are diminished; as observed, for instance, in acute and severe inflammations of serous tissues, and as in acute rheumatism.

In the second class the corpuscules are increased, while the fibrine is diminished, as in typhus, small pox, and cerebral hemorrhage.

The third class comprises those cases or conditions in which both the fibrine and corpuscules are below par, and decidedly deficient, while the water of the blood is increased; as observed, for instance, in anemia, carcinoma, scrofula, chlorosis, and the true cholera.

The fourth class embraces those in which new matters are contained in the blood; as, for instance, in Bright's disease of the kidneys, and in all cases of chronic rheumatism, or wherever bile, or urea, or any other substance poisons the blood. Occasionally fat, and under certain circumstances a great variety of minute particles of other matters, may be observed in the human blood, by the aid of a good microscope. Therefore we know that the blood may be actually altered in material and quality, and therefore *may* sensibly change the working of a part, or of the whole of the electro-nervous batteries of that individual organism. And conditions which are so manifestly electro-nervo-pathological, as well as humoral, are known to be, in part at least, *corrected* by means of iron, quinine, phosphorus, and sulphur; or by farinaceous or animal food, exer-

cise, sunlight, and air; while very many others are *not quite reached* by any or all these rational, but, for the given case, insufficient means, until reënforced by the coöperating, and vitalizing in-workings of correctly employed currents of electricity. Moreover, in studying the minute relations of acute and chronic nervous diseases and derangements, we find presented to our notice several points of departure: —

First, we may find the general muscular and nervous electric circuit, also called "animal electricity," acting fiercely, irregularly, or perhaps very languidly; and either of these, *from the peculiar condition of the blood*, which in the one case renders it *a too exciting fluid*, for the health of that living galvanic-like organism; or, in another case, it is too feeble, or too much poisoned, perhaps, to act with any degree of efficiency; or we may have actual disease of the cord, and brain, and ganglia parenchyma; or of the peripheral parenchyma, and its media, (nerves,) which serve as conductors or telegraphs to connect the outer stations of minute vitalized voltaic batteries with the great cervical ganglia and brain. Besides, we must bear in mind the natural nervo-electric relations of nutrition, growth, and repair, as well as the *abnormal* products, or deposits, occasionally produced simultaneously with the deviations from the usual standard of actions as observed in health.

The essential character of inflammation is as little understood as fevers; and these two great classes of diseases are essentially different. The former is an abnormal action, tending to the formation of pus. Now pus is an organic cell; which, however, is very different from the ordinary ultimate cells, of which the various parts of the organism is constructed. When inflammation occurs, we have some greater or less deviation of the ordinary sensations, increase of temperature, and great vascularity. In fever, we have that sort of almost total absence of motion, which is termed "prostration." But this is not in any sense paralysis. The feelings are, for the time, unbalanced, perverted, and morbid. Certainly, all this goes to show the extensive implications of the electro-nervous system and apparatus in these universal diseases. In actually developed phthisis, and

scrofula, we see the greatest deviation of normal cell-life, while there is but very little nervous phenomena. In these maladies we find extensive *organic* disease, yet little pain, little impairment of motion or of sensation, when compared with the same amount of change in the *electro-nervous affections*, as, for instance, rheumatism. Cancer, like scrofula and inflammation, consists of *abnormal* organic cell; which, however, differs from both tubercle and pus in its physical character. Syphilis is also a malady of abnormal organic cell; the *virus* of which influences the entire cell-life of all that individual organism. Now, all these and other organic diseases appear to me, to *proscribe* any sort of use of, or hope from the use of any form of electricity employed as a therapeutic agent.

Professor Bennet, of Edinburgh, says, "Every known fact convinces me, — and the progress of science only adds strength to my convictions, — that we must ascribe the ultimate *cause* of inflammation to a degenerate state, arising *from a derangement of those forces* which regulate the nutritive powers of the living economy," and that the only correct definition of inflammation itself is, "an exudation of the normal *liquor sanguinis*." It is in vain that physiologists seek in the alterations of the vessels on the one hand, or in the morbid changes in the blood on the other, for the primary cause of this important condition. Facts prove that both are more or less affected; and they also show that neither the one change nor the other, nor yet the two combined, constitute inflammation. The vital *nervo*-electric properties of the tissues (understanding by these the little known and less defined conditions necessary for carrying on the nutritive process) are in all such cases *deranged;* and such alteration is the very *cause* of the changes which have been referred to, and not the effect.

The increased heat manifested after certain manipulations with electric currents on the living skin and flesh is not simply due to a greater afflux of blood to the vessels of the part so treated; for it is proved, that these are *not expanded* by *electro-magnetic* currents, certainly, if applied directly over the muscles, but are then rather constricted for the time, and therefore

contain less blood than normal, and yet there is more heat. Hence, if the heat does not arise from an action on the skin, nor yet from the influx of blood and fluids, it must be due to an augmentation of those nervo-electro-chemical changes which we call *vital chemistry*, and which are continually going on in all the tissues of the living organism, but more particularly in the *muscles*, and which action constitutes their very existence, growth, and life, their wear and repair, or exhaustion and nutrition, much as if an engine were so arranged and endowed as to draw its own water and coal, clear its soot and ashes, oil its own axles, and do its own forging timely, and in due proportions.

It is, then, well ascertained that the heat developed in living tissues after treatments by electro-muscular contractions, as more frequently noticed in the paralytic and atrophied, is an increased *vital* and *catalytical* action among the tissues and liquids, rather than a chemical action on the surface of the skin. This proposition is also fully confirmed by various pathological experience.

Two results are determined from the effects of electric currents on enfeebled, relaxed, or paralyzed muscles; and the first is, an *increase of heat*, and the second, an *increase in size*, of the parts so acted upon. The solid structure of muscle fibres *imbibes* a fluid from the blood, which is discovered to be, at times, variable in composition. If this muscular fluid is taken from a muscle that has been long at rest, it will be found to give a *neutral* reaction; but after labor or active electric excitation of the muscle, the fluid will then give an *acid* reaction, in consequence of an increased absorption of oxygen, and consequent oxidation and formation of carbonic acid. This can be proved by actual experiment, if we measure the quantity of oxygen absorbed, and carbonic acid exhaled, by the muscular substance of the frog's thighs which have been skinned and suspended in closed glass vessels filled with air or oxygen; for we find that if the muscles in some of the vessels are electrized, and the others not, the quantity of the gases absorbed and exhaled by the electrized muscles is found to be more than double that absorbed and exhaled during the same time by the quiescent muscles in the other vessels. From many fair trials, we know, at least, that

this difference occurs in the living muscles of man, and that by the augmentation of chemical changes, the heat of the part is sensibly increased. More blood is attracted to the capillary vessels, particularly those of the muscular substance whereby the bulk of the muscles is expanded and actually increased. The very fact that there is more blood attracted to these tissues produces, under this more lively induced action, an increased nutrition.

Giddiness is usually caused by a deficient supply of blood to the head. Exhaustion of nervous energy will likewise produce it. Cold will produce it. So will suddenly changed currents of galvanism. This, then, it is highly probable, is an electro-physiological phenomenon. Insensibility arises from the same causes that produce giddiness, but it requires a greater degree. In giddiness, the nerve batteries of the brain appear to be disturbed or unbalanced; but where there is insensibility they seem almost suspended to the last degree. The blood to the brain is deficient or deteriorated, and unfit for the purpose, so that the sensorium nerve-battery cannot act. No impression can be received or responded to, when the blood is vitiated *to a certain degree*, as by carbonic acid, chloroform, narcotics, or poisons. It is, perhaps, scarcely necessary to say that this may occur from an organic lesion somewhere between the centre and periphery. Now, if these occur with a state of atony, the iron preparations, with nutritious food, are the best means for restoring the usual constituents of the blood. If in the *strumous* patient, cod-liver oil will the better reëstablish the peripheric portion of the electro-nervous arrangement. In all cases, a judicious employment of *electricity, in connection with* these other rational means, can be a powerful auxiliary.

### *Effects of Electricity on the Fibre-cells in the Living Person.*

Extensive researches have been made to determine the precise action or function of muscular fibre-cells, and the effects of electricity upon them. The action is peculiar. The distinguishing characteristic between the actions of animal muscular

fibre, and organic contractile fibre-cells, when under the influence of electric currents, is, that the former respond *promptly*, while the latter respond *only after an interval, and that deliberately*.

This was ascertained by Dr. Nysten, during the first French Revolution, when the guillotine furnished him most ample opportunities for just such observations. More recently, Pro-

Fig. 29. Muscular Fibres — magnified 600 diameters.

1. Is a Muscular Fibre of *Animal Life* enclosed in its sheath of myolemma; this is a voluntary muscle fibre.
2. Is an Ultimate Fibril of the same, highly magnified.
3. A more highly magnified view of No. 1, showing the true nature of the Longitudinal *Striæ*, as well as the mode of arrangement and formation of the transverse *Striæ*. The myolemma is so thin as to permit the ultimate fibrils of molecules to be seen through it.
4. Shows a Muscular Fibre of *organic life*, with two of its *nuclei*, taken from the muscular coat of the human urinary bladder, and magnified 600 diameters.
5. Shows again a Muscular Fibre of *organic life*, from the muscular coat of the stomach, magnified the same.

fessors Kölliker, Gerlach, Heule, Harless, and others in Germany, mainly confirmed his conclusions; but like nearly all early electro-physiological investigations, the results obtained on this point did not exactly agree, because each experimented with a different kind of current, and hence each came to modified conclusions. But we can sum up the final and most reliable results in a very few words, viz.: —

The muscular fibre-cells respond more readily to an interrupted than to a continuous current, and hence *show more action* under induction currents than under continuous galvanic currents. If the latter is applied to them, however, there is a

contraction at the closing of the circuit, during its continuance, and at its opening. The intensity and duration of the produced movements in the organic fibre-cells are determined by the intensity, interruptions, and duration of the current's action.

Furthermore, if an active electric shock, whether Static, Galvanic, or Faradaic, be applied to a voluntary muscle, it instantly contracts, and then as instantly relaxes. But, in contrast to this, the contractions produced in the fibre-cells by the electric stimulus are not simultaneous, or instantaneous with the closing of the circuit, but only *after* a little time, and while there is still action of the current upon the tissue; and this effect *lasts a little after* the cessation of the current. But the most remarkable phenomenon in regard to the movements of the fibre-cells as brought about by electricity, is, that they *occur only in an order which corresponds to their peculiar physiological purpose, wherever they properly belong*. Thus, if we moderately electrize the intestines, then only *peristaltic* movements are induced downwards; but never do we thus get movements from the rectum towards the mouth. If the ureters are Faradaized, the wavy movements are seen to be from the kidneys towards the bladder, but never in the opposite direction. Dr. Althaus says this will invariably occur, whatever may be the kind, intensity, or direction of the electric current, and whatever may be the point of the cell-fibre tract to which the electrodes are applied.

Now, the difference between what is called vascular and non-vascular tissues (to which latter division articular cartilages belong) is known to be so slight, that the method by which this structure is nourished is no longer doubtful. The blood being conducted to every tissue by its ordinary vessels, each tissue extracts, or rather *imbibes*, the material requisite for *its* own best nourishment; the only difference between the vascular and non-vascular parts being determined by the space through which this process of imbibition takes place; in the latter, the vessels do not perforate its substance. The nucleated cells, however, through which all the living structures are formed, and grow,

still do absorb from the vessels, however distant, their quantum of nourishment; and in articular cartilages, these cells are as active as in any other tissues.

The method by which these blood vessels supply the articular cartilages may be thus briefly described, the necessity to understand their vascular supply being evident when their pathology is looked into. That the principal source of supply is derived through their bony attachment, the researches of Birkett, Toynbee, and others have full well demonstrated. The vessels at their bony base form loops, and yield the required nourishment "somewhat in the same way as the epidermis scales are nourished upon the vascular loops of the corium." The vessels ramifying into the synovial membrane furnish, at their circumference, to their adjacent surfaces the sufficient supply.

It is clear, then, that structures deriving their nourishment through other adjacent tissues must depend much upon the *integrity* of these tissues; and here such an example is witnessed, particularly in old people. Articular cartilages are liable to diseases which may all be classed as the enlarged or *hypertrophied*, or *atrophied*, that is, wasted. They are peculiarly liable to granular, fatty, and fibrous degeneration, but not to inflammation. Now, all these seem to arise either from perversion of nutrition, or else diminished or arrested nutrition, but never through excessive vascular supply, or through single excess of function. Hence the reasonableness of electric currents, properly applied, being of the greatest service, in all such joint affections, *when not complicated* with inflammation or ulceration of the adjacent tissues.

### *Œsophagus.*

It is now known, from experimental demonstration and from results in practice, that electric currents here produce marked contractions, both in the longitudinal and circular fibres of the contractile fibre-cells, or of muscle fibres, or both. At least, such contractions are produced in the œsophagus, whatever be the nature of the structure that contracts. It is said that the

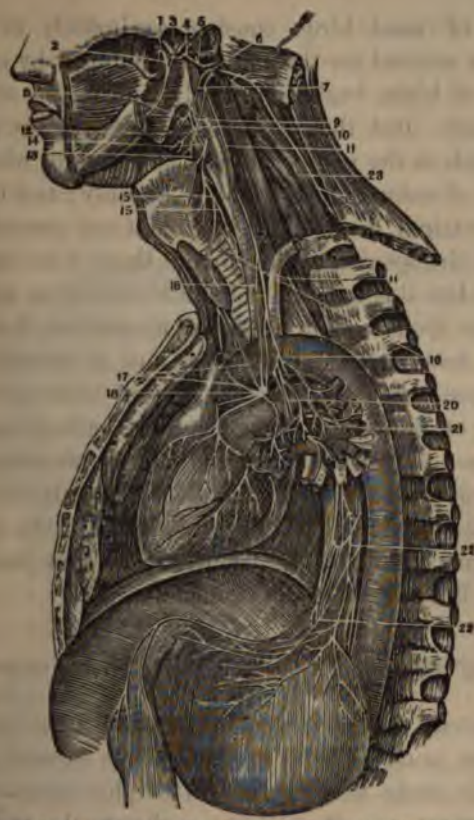


Fig. 36. A View of the Position of the Pneumogastric Nerve, the Glosso-Pharyngeal, and Spinal Accessory Nerves, or the Eighth Pair.

1. The Inferior Maxillary Nerve.
2. The Gustatory Nerve.
3. The Chorda Tympani.
4. The Auricular Nerve.
5. Its communication with the Portio Dura.
6. The Facial Nerve coming out of the Stylo-Mastoid Foramen.
7. The Glosso-Pharyngeal Nerve.
8. Branches to the Stylo-Pharyngeus Muscle.
9. The Pharyngeal Branch of the Pneumogastric Nerve descending to form the Pharyngeal Plexus.
10. Branches of the Glosso-Pharyngeal to the Pharyngeal Plexus.
15, 15. Communication of the Superior and Inferior Laryngeal Nerves.
16. Cardiac Branches.
17. Cardiac Branches from the Right Pneumogastric Nerve.
18. The Left Cardiac Ganglion and Plexus.
19. The Recurrent or Inferior Laryngeal Nerve.
20. Branches sent from the curve of the Recurrent Nerve to the Pulmonary Plexus.
21. The Anterior Pulmonary Plexus.
22, 22. The Œsophageal Plexus.

œsophagus of most birds consists exclusively of fibre-cells; therefore we account for the motions produced by electricity in the throats of birds, beginning slowly, and lasting after the current is opened. But there are some birds, as the *rodentia*, or *gnawers*, such as the eagle, vulture, and parrot, whose œsophagus consists of animal muscle mainly, or only; and hence, when such are electrized, there are seen prompt and powerful contractions, and at the opening of the current there is as instantaneous dilatation. But this does not obtain so clearly in man, because in the human species, as in almost all mammalia, the œsophagus consists of *both* organic fibre-cells, and of animal muscular fibres. Hence, when the electric current touches the œsophagus directly or indirectly, the effects are both prompt and prolonged; i. e., they partake of the mixed phenomena arising from the contractile fibre-cells and from muscular fibre. If the action of the electric current be prolonged a little, or is made a little stronger, then the contractions are not limited to the throat only, but extend to the stomach.

### *Effects of Electric Currents on the Muscles respectively.*

If we electrize the muscles of the face of a person just dead, and while the muscles have retained their natural excitability, we can truly study the mechanism of physiognomical expressions, because we can thus excite each muscle, and cause it to contract much the same as when they are put under the action of thoughts, passions, habits, or *prevalence* of character. The muscles are inclined to retain, during their repose, some degree of the predominance of tonic force exercised most repeatedly and constantly upon them, and this etches or carves in every human face its own peculiar expression and character, which we term physiognomy. Dr. Duchenne has made *this* subject his very special study, and from him we obtain many highly interesting facts.

Fig. 31. Muscles of the Face and Neck.

1. Anterior Bellies of the Occipito-Frontalis.
2. Orbicularis, or Sphincter Palpebrarum.
3. Nasal Slip of Occipito-Frontalis.
4. Anterior Auriculæ.
5. Compressor Naris.
6. Levator Labii Superioris Alæque Nasi.
7. Levator Anguli Oris.
8. Zygomaticus Minor.
9. Zygomaticus Major.
10. Masseter.
11. Depressor Labii Superioris Alæque Nasi.
12. Buccinator.
13. Orbicularis Oris.
14. The denuded surface of the Inferior Maxillary Bone.
15. Depressor Anguli Oris.
16. Depressor Labii Inferioris.
17. The Portion of the Platysma-Myoides that passes on to the Mouth.
18. Sterno-Hyoideus.
19. Platysma-Myoides. It is wanting on the other side of the Figure.
20. Superior Belly of the Omo-Hyoideus near its insertion.
21. Sterno-Cleido-Mastoideus.
22. Scalenus Medius.
23. Inferior Belly of Omo-Hyoid.
24. Cervical Portion of the Trapezius.

When the muscle *frontalis* is slightly contracted, the face cheers up; then, when more contracted, its expression is changed to surprise, and then even to doubt; if in the highest degree of contraction, and assisted by other muscles, it produces the agreeable surprise, and so on to terror. This muscle wrinkles the forehead; therefore, when it is paralyzed, the wrinkles cannot be produced. The *paramidalis nasi*, which is but a nasal elongation of the frontalis, acts, however, as the antagonistic of the frontalis, and when contracted, therefore, gives the expression of sadness; when more contracted, a threatening aspect.

When the *orbicularis palpebrarum* and *corrugator supercilii* are both contracted, there is produced the expression of reflection and perplexity; and when aided by the pyramidalis, there is the expression of malice. We see that the *platysma myoides* gives the expression of pain; and when united with the frontal muscle, it expresses terror; if with the pyramidalis, then there is rage.

The electro-contraction of the *triangularis nasi* gives the voluptuous expression; while that of the *zygomaticus major* always yields those expressions of mirth from the slightest twinkle of a roguish smile to the most extravagant laugh; and if this is united with the frontalis, there is then a modification to the agreeable surprise; but if with the *platysma myoides*, there is the restrained, "can't-help-it" or threatening laughter. The contraction of the *zygomaticus minor*, on the contrary, gives the melancholy air to the countenance; and the *levator alaque nasi*, with the *labii superioris*, are the crying muscles, that in children produce such an ugly grimace. The *levator menti* is the only muscle in action when one mutters or repeats in audible prayers, as is done in Roman Catholic churches. It is by the contraction of the external fibres of the *orbicularis oris* that the lips are protruded, as for pouting, kissing, and whistling; while the internal fibres press the lips against the teeth. Then the contraction of the *triangularis oris* gives the deeper expressions of sadness. In children it is seen in play as the precursor of tears; but in its maximum of action there is presented the striking expression of disgust.

The *trapezius* arises from the inner third of the occiput, and is attached to the last cervical and whole of the dorsal vertebræ, also to the scapula, with clavicular attachment from occiput to clavicle. It exercises action upon the shoulder in *three directions;* for its clavicular and occipital fibres draw the shoulder upward; its upper dorsal, cervical, and scapular fibres draw it backward, i. e., to the spine; its dorsal fibres draw it a little downward. If, then, the *inferior* portion of the *trapezius* be Faradaized, the base of the scapula is drawn backward, and its inferior angle downward. If the *middle* portion be thus excited, the scapula is elevated, and its inferior angle is drawn farther from the spine. If the *clavicular* portion of this muscle be Faradaized, then the head is drawn towards the side acted upon by the current, and besides, it is drawn slightly backward, so that the chin is turned a little towards the opposite side, and the clavicle is also elevated by it. The clavicular portion of the trapezius is exceedingly responsive by electric contractions, because it is animated by a double set of nerve fibrils, and that is, both from the spinal accessory and from the cervical plexus. Therefore unusual care is required to proceed here with the currents in moderation and gentleness at first. If we apply the electric stimulus to the clavicular portions of both trapezius muscles, i. e., by directing one electrode to each at the same time, — the head is drawn directly backward.

The *latissimus dorsi* arises from the spinous processes of the lower dorsal and of all the lumbar vertebræ, also from the sacrum, ilium, and four lower ribs, and is inserted into the bicipital grooves of the humerus. Hence the action of this great muscle tends to draw the shoulder back upon the spine, *or the spine laterally towards the shoulder.* It passes over the inferior angle of the scapula, and by pressing upon it, steadies it. If it is Faradaized, it draws the arm downward and backward; the scapula is at the same time approximated to the spine, but not elevated. The trapezius and the latissimus dorsi form the first and outer layer of the muscles of the back.

When the *deltoid* muscle is electrized, it *abducts* the humerus, but does not elevate it even in that direction above the horizontal

Fig. 32. A View of the Muscles of the Back; the first layer, as shown after the removal of the integuments that cover them.

1. Occipital Origin of the Trapezius.
2. Sterno-Cleido-Mastoideus.
3. Middle of the Trapezius.
4. Insertion of the Trapezius into the Spine of the Scapula.
5. Deltoid.
6. Second Head of the Triceps Extensor Cubiti.
7. Its superior Portion.
8. Scapular Portion of the Latissimus Dorsi.
9. Axillary Border of the Pectoralis Major.
10. Axillary Border of the Pectoralis Minor.
11. Serratus Major Anticus.
12. Infra-Spinatus.
13. Teres Minor.
14. Teres Major.
15. Middle of the Latissimus Dorsi.
16. External Oblique of the Abdomen.
17. Gluteus Medius.
18. Gluteus Minimus.
19. Gluteus Magnus.
20. Fascia Lumborum.

line, which will be verified by experience in this department of practice. It will be noticed that if only the anterior fibres of this muscle are touched by the current, the arm is started forward and inward, and carried to an elevated posture. But if directed only to the posterior fibres, then the humerus is started backward, and if the current be pretty strong, the hand will also be carried back, and even raised, and retained high up the back. When aided by the *serratus magnus*, the deltoid not only lifts, but sustains, the arm elevated; and when aided also by the joint action of the middle portion of the trapezius, it, — or rather they, — elevate the arm to the head, and to all postures above the horizontal line of the shoulder. The deltoid is exceedingly prone to pains and palsy, and occasionally suffers from atrophy.

The *rhomboideus major* arises from the spinous processes of the four upper dorsal vertebræ, and is inserted into the posterior border of the scapula. Its action is to draw the scapula horizontally back upon the spine, and the spine laterally to the scapula. The *rhomboid minor* arises from the last cervical vertebra, and is inserted into the edge of the triangular surface of the posterior border of the scapula. The action of this muscle is to draw the scapula obliquely upward, — i. e., towards its cervical origin; and these two muscles especially influence the dorsal "*curvature*" of the spine. But there is the *levator anguli scapulæ* also, that goes to make up the second layer of muscles on the shoulders and back, which arises from the transverse processes of the four upper cervical, and is inserted into the upper angle and posterior border of the scapula. The action of this muscle is to draw the scapula upward towards this cervical region, and the spinal column of that region downward towards the scapula. If, then, the *rhomboid* be electrized, as where the *trapezius* is destroyed by palsy or atrophy, the scapula is raised and also rotated on its axis, so that the inferior angle is nearly in the same line with the external angle; and by the tonic contractility of this muscle, it fixes the base of the scapula firmly against the walls of the thorax. If the *rhomboid* is also atrophied or palsied, then the base of the scapula projects from the thorax, and becomes very prominent under the skin, so that a remarkable cavity is formed between it and the spine.

The *serratus magnus* is mainly an inspiratory muscle, because it acts in concert with other muscles, to elevate the ribs; from which, indeed, it arises. It also contributes to lift the *humerus*. But the *serratus posticus inferior* is attached to the spinous process of the two lower dorsal, and the two upper lumbar vertebræ, and is then inserted into the angles of the four lower ribs. The action of all these muscle fibres is for depressing the ribs, and concurs in expiration, and at the same time slightly aiding a slight rotation of the ribs upon the vertebræ. The *serratus posticus superior* arises from the upper dorsal and one lower cervical vertebræ, and is then inserted into the margin of the second, third, fourth, and fifth ribs. Its action is directly antagonistic to the *serratus inferior*, for it tends to raise the ribs upon the spine, and so elevate the chest as to concur in inspiration. If it is permanently contracted, it would produce *dorso-lumbar curvature* of the spine towards that side; if paralyzed, the curvature would be towards the other side. The serratus magnus, being a broad, flat muscle, arising from the first eight or nine ribs by digitations, and inserted into the spinal border of the scapula, when normal, sustains the scapula forward, and contributes to keep up its external angle against the weight of the upper arm, which is so continually tending to depress the external angle of the scapula. We see, then, that the *trapezius* and the *serratus* are both opposed to this depression. But if the trapezius is paralyzed, or atrophied, or but fatigued and relaxed, then the external angle of the scapula is allowed to fall, more or less, while its inferior angle rotates upward and backward, so as to approach or override the spinous processes. And if the serratus magnus be also involved, as in a wasting palsy, then the external angle becomes even more depressed, while the inferior angle rises quite to the level of the external angle, and projects or hangs off hideously from the ribs.

The *splenius colli* and *splenius capitis* are two muscles that have a common origin at the six upper dorsal and last cervical spinous processes; then, again dividing, the latter goes to be inserted in the mastoid process of the temporal bone. They act

conjointly with their fellows, the antagonizers on the opposite side, in staying the head erect; and they also rotate the head. These muscles are liable to paralysis on one side, and perhaps simultaneous contraction on the other. The electric excitement can well develop their physiological action.

The *sacro-lumbalis* takes its origin from the sacrum, ilium, and lumbar vertebræ, and is inserted into the angles of the six lower ribs. We must be aware, that its action is to keep the lumbar vertebræ *erect.* If its fellow on the opposite side is weakened, relaxed, or paralyzed, it will contract, or *vice versa*, and thus constitute a "*persistent lumbar curvature.*"

The *longissimus dorsi* also arises from the sacrum and lumbar vertebræ, and is radiated so as to be inserted into the angles of eleven ribs, and the transverse processes of all the dorsal and lumbar vertebræ. This muscle, too, is to be reached by the electric stimulus. If it is unbalanced with its antagonizer, it contributes to a "*lumbar curvature*" of the spine. Therefore we can say, not empirically, but rationally, that "spinal curvatures" from these causes, or complicated with these muscle deviations, can be cured by electric currents, or, *at least, aided in their cure.*

The electro-muscular contraction *test*, thus aids us in determining the *exact* physiological action of all the muscles of the back, (which are liable to be not only neuralgic or rheumatic, but also enfeebled, relaxed, palsied, and even *atrophied*, and hence, also, involved in many spinal curvatures, and other affections,) but perhaps not so familiar to the profession generally. They can be summed up thus: —

1. In the *cervical region* we find that the grand normal action of the *trapezius* is to draw the cervical spine towards the shoulder, and the shoulder towards the cervical portion of the spine. The *levator anguli scapulæ* lifts the scapula towards the head, and draws the head over laterally towards the back shoulder. The *rhomboideus minor* draws the scapula upward and backward to the spine, and the spine towards the scapula. The *splenius capitis* draws the head over obliquely, i. e., laterally and posteriorly. The *splenius colli* draws the cervical vertebræ off

Fig. 33. A View of the second layer of the Muscles of the Back.

1. Trapezius.
2. A Portion of the tendinous ellipse formed by the Trapezius.
3. Spine of the Scapula.
4. Latissimus Dorsi.
5. Deltoid.
6. Infra Spinatus and Teres Minor.
7. External Oblique of the Abdomen.
8. Gluteus Medius.
9. Gluteus Magnus of each side.
10. Levator Scapulæ.
11. Rhomboideus Minor.
12. Rhomboideus Major.
13. Splenius Capitis.
14. Splenius Colli.
15. A Portion of the Origin of the Latissimus Dorsi.
16. Serratus Inferior Posticus.
17. Supra Spinatus.
18. Infra Spinatus.
19. Teres Minor.
20. Teres Major.
21. Long Head of the Triceps Extensor Cubiti.
22. Serratus Major Anticus.
23. Internal Oblique of the Abdomen.

laterally. The *sacro-lumbalis* aids to raise the ribs upon the cervical vertebræ, and also draws the cervical vertebræ obliquely downwards. The *serratus posticus superior* lifts the ribs upward upon the spine, and draws the ribs firmly against the spine. The *cervicis transversalis* and the *complexus* help in sustaining the head and neck erect. The *tracelo-mastoideus* draws the head sidewise, and draws the cervical spine towards the side of the head. The *semi-spinalis colli* aids in a powerful perpendicular traction against the cervical vertebræ.

2. In the *dorsal region* we find that the *trapezius* draws the scapula almost horizontally towards the spine, and the spine towards the scapula. The *latissimus dorsi* draws the shoulder towards the dorsal vertebræ, likewise that portion of the spine towards the shoulder. The *rhomboideus major* here draws the scapula horizontally towards the vertebræ, and the spine to the scapula. The *serratus posticus superior* simply lifts the ribs upon the spine, and the *serratus posticus inferior* depresses the ribs. The *longissimus dorsi* creates an oblique action in the whole dorsal portion of the spine, which is lateral and posterior. The *spinalis dorsi* holds the spine perpendicularly erect posteriorly. The *tracelo-mastoideus* draws the cervical vertebræ obliquely. The *complexus* draws the head backward, sets it firmly, and holds it erect. The *splenius capitis* draws the head towards the dorsal spine, and the dorsal towards the head.

3. In the *lumbar region*, we observe that the *latissimus dorsi* draws the shoulder down towards the lumbar region, and that portion of the spine to the shoulder. The *serratus posticus inferior* simply draws down the ribs. The *sacro-lumbalis* exerts a powerful oblique action in the whole of the lumbar, and in a part of the dorsal region. The *longissimus dorsi* exercises an oblique influence along the whole of the lumbar vertebræ.

4. In the *scapular region*, it is noticed that the *trapezius* draws the scapula upward and backward; that the *levator anguli scapulæ* lifts the scapula towards the cervical region, and draws the spine downward towards the scapula; that the *rhomboideus minor* draws the scapula towards the dorsal spine, and the spine to the scapula; that the *rhomboideus major*

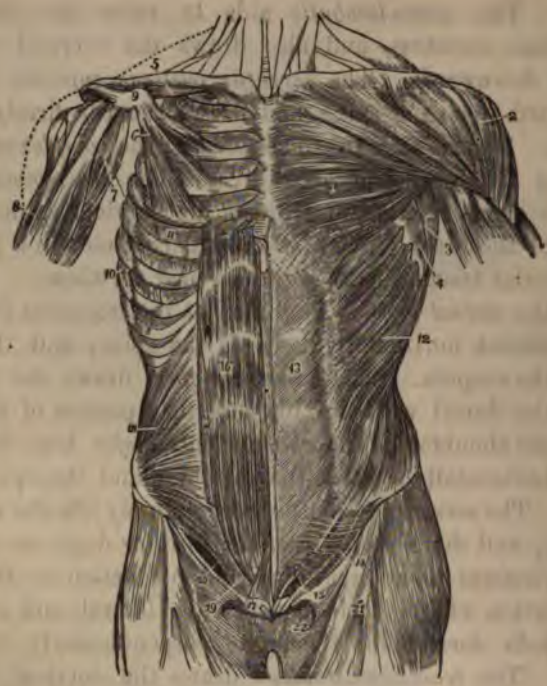


Fig. 34. Muscles of the Front of the Trunk. On the left side is a View of the Superficial Muscles; on the right side is a View of the Deep Muscles.

1. Pectoralis Major.
2. Deltoid.
3. Anterior Edge of the Latissimus Dorsi.
4. Serrated edge of Serratus Major Anticus.
5. Subclavius Muscle.
6. Pectoralis Minor.
7. Coraco-Brachialis.
8. Biceps Flexor Cubiti.
9. Coracoid Process of the Scapula.
10. Serratus Major Anticus, where the Obliquus Externus Abdominis has been removed.
11. External Intercostal Muscle of the Fifth Intercostal space.
12. External Oblique of the Abdomen.
13. Its Tendon. The Median Line is the Linia Alba.
14. The Portion of the Tendon of the External Oblique, called Poupart's Ligament.
15. External Abdominal Ring.
16. Rectus Abdominis.
17. Pyramidalis.
18. Internal Oblique of the Abdomen.
19. Common Tendon of the Internal Oblique and the Transversalis.
20. Crural Arch.
21. Fascia Lata Femoris.
22. Saphenous Opening.

draws the scapula horizontally to the dorsal spine, and that portion of the spine to the scapula.

Fig. 35. Muscles of the Trunk, lateral view.

1. Latissimus Dorsi.
2. Serratus Major Anticus.
3. Upper Portion of the External Oblique.
4. Two of the External Intercostal Muscles.
5. Two of the Internal Intercostal Muscles.
6. Transversalis Abdominis.
7. Fascia Lumborum.
8. Part of the Sheath of the Rectus, and Aponeurosis of the Transversalis.
9. The Rectus Abdominis cut off, and in its Sheath.
10. Rectus Abdominis of the Right Side.
11. Crural Arch.
12. Gluteus Magnus, Medius, and Tensor Vaginæ Femoris, covered by the Fascia Lata.

5. In the *costal region*, it is observed that the *latissimus dorsi* tends, on the whole, to draw the dorsal spine into an oblique lateral position; that the *sacro-lumbalis* tends to hold the spine erect, and also make an oblique action in the lumbar vertebræ. The *serratus posticus superior* and the *cervicalis ascendens* tend to lift the ribs, and draw the cervical spine obliquely over and downward.

6. In the *abdominal region*, we see the *external oblique*, acting powerfully in the direction of its fibres, *from* the pubis *towards* the scapula; that the *rectus abdominis* acts perpendicularly in and near the anterior median line; that the *internal oblique* produces a deep together-drawing that radiates from the crest of the ilium, upward to the lower ribs, forward to the linia alba, forward and downward towards the pubis; and that this, together with the external oblique, acts most promptly and powerfully to the electric stimulus.

7. In the *pelvic region*, the *latissimus dorsi* is seen to draw the whole spine from the upper dorsal to the lower lumbar vertebræ, together with the ribs, in an oblique downward direction; and that the *longissimus dorsi* has a decided indirect action,

laterally, over both the dorsal and lumbar portions of the spine; while the *sacro-lumbalis*, acting from the broad edge of the pelvis as a fixed point, powerfully draws the body over laterally, as well as exerts a lateral effect on the whole lumbar region.

If we test the muscle *biceps brachii* with *moderate*, i. e., painless Faradaic currents, we obtain scarcely any visible effects by placing both the electrodes on the ends of the muscle fibres; in no case, however, do we thus effect a perfect persistent contraction, or even a bending of the forearm. But if, now, without increasing the strength of the same current, we remove the electrodes, and place one on the middle of this muscle, while with the other we seek the point where the *musculo-cutaneus* nerve goes behind the muscle, — this taking place, as is well known, in the region of the upper quarter of the inner border of this muscle, — it may happen that instead of obtaining the expected *contraction* of this muscle, and consequent bending of the forearm, we produce effects on the muscle *pronator teres*, or even on the flexors of the fingers. When this is the case, we know that the electrode was too far back, and the current has therefore touched the nerve *medianus;* or we may even obtain an action on the muscle *triceps* when the current has reached the nerve *radialis*. In either case we must move the electrode a little forward and upward, when we shall find that point out of which a fair contraction that flexes the forearm can be produced, *and that without the least pain*, if no large branches of skin nerves are embraced by the electrodes.

Again, if we make a similar trial on the muscle *trapezius* by placing one electrode just beneath the *occiput*, so as to rest upon the upper end of this muscle, while the other electrode is planted over its insertion in the *spina scapula*, and consequently in the direction of the muscle fibres, we obtain no effects of importance, except an aching pain in the shoulder blade, or in the occipital region, i. e., if an occipital nerve has been touched by the current. But if we now leave either one of the electrodes where it is, and seek with the other over the anterior border of the muscle, in front of the shoulder, for that point where the nerve *spinal accessory* of Willis passes under the edge of the

*trapezius*, we at once obtain a very powerful and painful bending of the head backwards, or laterally, or else a lifting of the shoulder, according as we have left the first electrode near the back of the head, or near the shoulder.

If we make the trial on the *sterno-cleido-mastoideus*, by placing the electrodes on the respective ends of that muscle, and using, as in the former trials, the Faradaic currents of moderate strength, we obtain no nodding of the head; but if we increase the current we get a contraction, and perhaps this is accompanied with some pain in the region of the ramification of the main *auricular* branch of the *cervical plexus*. But if we place one of the electrodes on about the middle of the muscle, and then seek with the other along the outer border of the muscle, that *point* where the nerve *accessorius* of the eighth pair passes under the back edge of that muscle, we immediately obtain strong and painful nodding of the head, accompanied perhaps with a *by-working* on the muscles of the tongue and throat that depend upon the nerve *hypoglossi*, if we touch or include that nerve ganglion. This, however, can and should be avoided.

There are persons with peculiarly torpid facial muscles, on whom the placing of these electrodes with this current in the course of the muscle fibres, produces almost or quite no effect whatever; but contractions are quickly produced by placing one of the electrodes on the middle of the given muscle, while the other hunts the exact spot where the branch of the nerve *facialis* (*portio dura*) enters it. This is readily tried on any one, and safely too, by testing the muscle *depressor anguli oris*, or the muscle *frontalis*, or the *attollens auriculæ*.

In many muscles we often find, as, for instance, in the *orbicularis palpebrarum*, the placing of both electrodes to the same muscle is not always altogether advisable, on account of the in-working of the then necessarily strong current on the eyeball. The isolated, painless, and harmless together-drawing and pursing of this muscle is better obtained by placing one electrode over the *entrance spot* where the nerve enters this muscle, which is at its outer border, while the other electrode may be somewhere near, so as to embrace the muscle fibres, and that

with a very gentle current, for the great excitability of these eye muscle nerves, renders it quite sufficient for one electrode, or the route between the two electrodes, to merely graze some of the nerve twigs, or muscle fibres to produce its complete physiological action.

If we return to the muscle *pectoralis major*, and place one electrode on almost any part of the muscle, while with the other we seek the spot at its upper border and just under the *clavicle*, where the nerve *pectoralis anterior* comes from under that bone, we shall produce prompt and powerful together-drawings of the *whole* muscle. And this can be done if the first electrode is placed *on* the muscle, or even *beyond* it. Quite analogous results can be obtained on the muscle *serratus anticus*, or on the fleshy muscles of the forearm, or of the leg. Here we cannot but notice some difference between the excitability of the muscles that partake in the acts of respiration over those of the extremities, as the former are so much the easier to affect; but in every case we shall observe the bearing and importance of the increased effects produced by the same means, used by different methods; i. e., by not so strictly and invariaby following the "*localized method*," according to Dr. Duchenne, but calling to our aid *also*, on every proper occasion, the appeal to the muscles *rather through the nerve branches or nerve trunk*. This, in my judgment, after no small clinical practice, has, I must say, a decided preference, both for immediate visible or sensible effects, but *much more for the profound and lasting impression which in effect, we know is the cure*. Herewith I wish to urge the importance, then, of not being always satisfied with simply bringing a portion of the superficial muscle fibres, or the smaller terminal nerve fibrils, under the influence of the electric current; but we are to endeavor to reach *also* the nerve branching, and even the large nerve trunk of the part, that this subtle current may traverse them for a given time in a certain guided direction; but more particularly must we seek *that point where the motory nerves have their entrance place into the muscle*. It is from such a point,—besides these general and specific *rules*, a point or points on the surface of the body and limbs, whose lati-

tude and longitude must be familiarized by experience in practice, and, still better, by systematic pre-trials on the *recent* subject, and on healthy persons, — that we can govern the action of the muscles most surely, most completely; and besides that, and which is of far more importance, to my mind, disturb and break up the abnormal polarity of the nerves most profoundly; thus leaving them in a condition so that their natural equilibrium of function can be by nature's tendencies again established for permanency.

If we desire to embrace in the current all, or as nearly all the larger branches of the nerve as possible, we must place one electrode over the highest reachable place for the entrance nerve, and the other over the forks of the first large radiating branches, as they enter and spread in the muscle, which will *usually* require the placing of the second electrode not far from the first.

It appears that Dr. Remak, the distinguished medical electrician of Berlin, and Dr. Duchenne, the great French medical electrician, recently met in Paris and made trials of their different methods of operating on the same subjects, for the same diseases, and with the same induction apparatus; which was the *Duchenne Machine* just alluded to. The patient had been suffering with lead-palsy. Dr. Duchenne made the first applications, and as soon as the flexors of the fingers were thus put in motion, the patient expressed insupportable pain, as he said, and as his countenance and actions also indicated. He was then requested to bring the muscle *biceps* into contraction, which he did by placing the electrodes — which, by the way, were large, wet sponges, stuffed into the hollow ends of common metallic handles — on the surface of that muscle and in the direction of its muscle fibres, when he obtained a visible contraction and plumping up of the muscle; but there was *no* bending of the forearm by it, while the features of the patient, in the mean time, betrayed great pain, and an unwillingness to have it prolonged. The intensity of the current of this powerful helix machine was then weakened down as much as possible, aided by means of a glass tube containing a column of water, which was interposed in the circuit. Remak then took the same elec-

trodes to electrize the same muscle of the same patient. He produced, it appears, at the first application of the current to the nerve trunk and *border point*, an accessory action on the nerve *medianus;* but after moving the upper electrode a little, *a perfect and painless contraction of the forearm was the result*, while the tetanic-like contraction indicated the true source of th phenomenon. The patient gave a thankful and astonished look at Dr. Remak, and answered his questions by saying, with a shy side glance at Dr. Duchenne, that he had not experienced the least painful sensation. Next, according to his own method, Dr. Remak tested the muscle *pectoralis* and the *rhomboideus* through their nerves, which he caused to contract most powerfully, yet without the least pain. It appears that Remak did not deem it expedient to show this trial on any other muscles and nerves than these two, which Dr. Duchenne had already observed in like manner before.

*Organs not provided with Nerves, Lymphatics, or Capillaries.* — The question, whether there is a real nervous connection between mother and fœtus, or child in utero, has long been agitated. Last year Dr. John O'Reilly, of New York, issued a most striking work, setting forth that the blood is partially oxygenized by the process of endosmosis and exosmosis; and that life is seated in, and is propagated by, the organic nervous system; so that these nerves control the previous blood processes, convey life wherever they go, and thus constitute a direct and continuous connection between mother and fœtus. More recently still, however, from some special investigations relative to "the structure of the umbilical cord and placenta," by Prof. Simpson, of Edinburgh, aided by the microscope and other nice modes of research, it appears to be demonstrated, that in the composition and structure of these parts there are no nerves, no capillaries, no lymphatics. The volume of the umbilical cord and fœtal portion of the placenta is formed of nucleated cellular tissue, traversed by the tubes of the umbilical arteries and veins and their placental subdivisions, while the whole cord and fœtal surface of the placenta are covered by a tunic of serous or seroid membrane.

Hence, in human anatomy, we have these exceptional temporary organs, of about two pounds weight, presenting a type of structure resembling that of some of the most inferior zoöphytes. The mother and her to-be child, two of the most highly organized beings in existence, are thus temporarily united together, during the intra-uterine life of the latter, by structures of the lowest zoölogical type.* Yet strong emotions, and some peculiar impressions of the former, may fatally or indelibly impress the latter.

But here, though reluctantly, we must close this chapter on Electro-Physiology. No one branch of medical science has so often and so deeply occupied the attention and study of the author as this. For every young medical man who loves his profession, and delights in understanding and curing disease, this is a most suggestive and profitable study. Indeed, let such be advised, that, in these days of improvement and learning, they cannot afford to neglect it. The more recent works of *Becquerel*, *Dubois-Reymond*, *Remak*, *Duchenne*, *Claude Bernard*, *Brown-Sequard*, *Radcliff*, *Pfluger*, *Altheus*, and *Richardson*, should be generally found in American medical libraries.

* Medical Times and Gazette, (October 29, 1864.

## CHAPTER IV.

### ELECTRICAL INSTRUMENTS FOR MEDICAL PURPOSES.

For therapeutical means we may have recourse to three *classes* of electrical instruments, viz., the Electric Machine, the Galvanic Battery, or the Induction Apparatus. There is quite a variety of instruments in all three classes, but we should choose them according to their *action*, and the *form* of the element they respectively produce. Electricity in motion, as we have seen, results from the reunion or neutralization of the two separated opposite electric principles. This may be *instantaneous*, *intermitted*, or *continuous*. In the former case it constitutes the simple *discharge;* in the second case a more or less *continuous* current; in the third, there are produced rapidly *interrupted* currents, which are usually as frequently alternated or reversed. Therefore the latter, as electro-magnetism, is best wherever we wish rapidly discontinuous and alternated currents. The galvanic battery is best for sustaining a more or less *continuous* current in a given direction. The friction "electrical machine" is the best for producing electricity of high tension, as sparks, or the instantaneous discharge, also called the "shock."

By the *electrical machine* we get a peculiar form of electricity for remedial purposes, possessing *great intensity*, while there is but *feeble quantity*. This machine may consist of a revolving cylinder, or plate of glass, which is submitted to the friction of cushions or rubbers. As a general thing, a plate machine is, for equal size, of far higher power than the cylinder; but it matters very little which form of friction machine is used. If we were going to purchase for practical purposes, we should de-

cidedly prefer the plate machine, and the plate should not measure less than twenty inches. The room for operating should be a dry one. When the air is moist it must be dried and warmed by furnace heat, or other means, and the glass plate, as well as the insulating supporters of the prime conductor, of the axle of the glass and of the rubber, should be rubbed with a hot, dry cloth, not only to free the machine of moisture, but also from dust, which is as hurtful as moisture to the preservation of electricity on insulated conductors. Hence, the apparatus, together with all the appliances about it, must be kept scrupulously neat and dry.

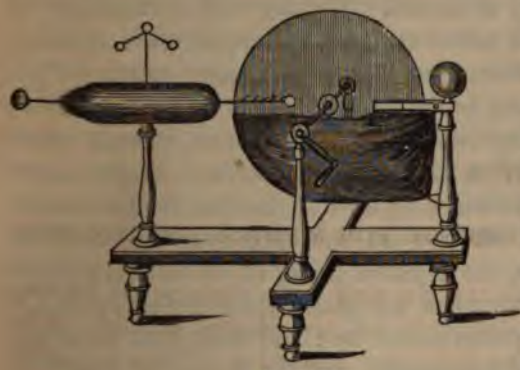


Fig. 36.

I have found that in humid weather, or when the atmosphere is negative as from an approaching storm, that if the glass plate is moistened with a very trifle of sweet oil, it is of advantage; also, that the surface of the rubbers must be from time to time renewed with an amalgam powder of zinc, or deuto-sulphuret of tin, which can be had of any philosophical instrument maker. Another arrangement or provision is also necessary; and that is, a good contact conductor with the actual moist earth, or a large body of metal. This should be some way adjustable near the machine, so as to be readily put in contact with the rubber, or negative pole, while we are charging the prime conductor *positively*, as also for drawing sparks from the patient, or for charging the Leyden jars; also, so that at another time it can be removed to the prime conductor while we are employing *negative* electricity from the rubber end of the machine, for the rubber is always the negative, and the prime conductor is positive. And here comes in the *law*, *that the one is never evolved without the other;* therefore, if we wish to use or accumulate the one, the

other must be as freely dissipated without hinderance, and if this point is well attended to, the power and uniformity of the machine will be greatly enhanced. The dry wall or chimney of the house is not always sufficient. A large copper wire leading to the moist earth, or connected with a water pipe, or gas pipe, by good metallic contact, is the most reliable. But, of course, where we wish to employ both electricities at once, we must not make either the rubber or the prime conductor communicate with the ground, but rather keep all well insulated. In every case the electricity is set free on the *surface* of the rubbed glass plate, or cylinder, the negative flying to the rubber, while the positive accumulates upon the glass, which induces it also by sharp points in the prime conductor; and from here we can accumulate even greater quantities still by means of Leyden jars. The power of the jar is in proportion to the size; i. e., a half gallon jar is twice as powerful as a quart jar, if each is fully charged; for the former will receive twice as many turns of the machine to charge it. If the outside tin foil coverings of two or more of these jars are put in communication, as, for instance, if set upon a sheet of tin foil, and at the same time the metal stems that communicate with the inner lining foil are joined also as by a chain, they thus become by this double connection as one jar, and can be charged and discharged through any one alone. This is called a *battery of friction electricity*.

Fig. 37.

Thus the inner coat of the jar receives positive electricity from the prime conductor, while negative electricity is then always accumulated on the outside of the jar, or conductor that leads it off. Now, if a communication is made between the inner and the outer coatings of the jar directly, as by means of a discharge, or indirectly, as through the human body, a neutralization of the two electricities takes place with a loud crack and flash. If the negative charge is required, the prime conductor must communicate with the *outer* covering of the jar, &c.; but usually it is the positive charge that we have to do with. If the jar is discharged through the human body, there is a violent,

sudden, and unpleasant sensation, which we term the *electric shock*. The strength of this shock is mainly in direct ratio to the extent of the metallic coating of the jar, and to the degree of high intensity with which that is charged and the susceptibility of the patient who receives it. This may be transmitted through one person, or even through a great number of persons in a chain, if the first person takes hold of the recently charged jar near its bottom, while the last person in the circle then touches with his finger the knob or ball on the top of the jar, and while they all hold each other by the hand. If several jars are properly united and fully charged, they might give a shock through the human body, by its action on the nervous system and the natural animal-currents that would exhaust them to such a degree, that it might prove as fatal as lightning itself.

The *discharger* is a necessary accompaniment of this machine, which consists either of stationary or adjustable metal arms, tipped with brass balls, and provided with a long glass handle. I find that *two* of these dischargers are more convenient than one, as for making discharges through the pelvis from the sacrum or lumbar region to the top of the pubis, in cases of dismenorrhœa. But it is necessary to approach the charged Leyden jar with the brass balls of the discharger *always in one order;* and that is, *first* make a ball to come in contact with the *outside of the charged jar*, *before* the contact is made with the knob on the top of the jar; for if the machine works well, and the reverse order is carelessly taken, i. e., to touch the top knob first, and then the outside of the jar the last, it will be very likely to break or to be perforated, and thus spoil the jar for further use. Another condition already alluded to, is necessary to succeed the best possible in charging a Leyden jar — for in medical practice but one or two at most are ever wanted. The outer foil of the jar must be in communication with the conductor to the earth, so as to utterly dissipate the negative electricity from outside the jar while it is being charged inside positively. But I must here take space

Fig. 38.

to remind you that it is believed that not an atom of positive electricity leaves the glass plate or cylinder that is rubbed, to pass to the prime conductor. The cylinder or plate is rendered positive by friction, and merely acts upon the electricity that is naturally in the prime conductor by induction, decomposing it into the two parts, and attracting the negative fluid, which accumulates in a state of high tension or elasticity, darts off towards the glass to combine with the positive fluid already commencing to be free on its surface, and so reconstituting the neutral or natural electricity. Thus the prime conductor is left powerfully positive, and so all things in contact with it, if also insulated, *not by acquiring electricity from the glass*, but rather by the *abstraction* of its own negative element, while simply *leaving* the positive electricity there.

When charging a Leyden jar, we can judge, after a little experience, how great is the charge from the number of turns of the machine, if we first ascertain that it is working well; but a more accurate means is Lane's discharging electrometer, or by Henley's quadrant electrometer.

To be prepared to use frictional electricity as a therapeutic, we need to be provided with the insulating Chair and Stool. The patient can be placed on the stool, but it is better to place him or her in the insulating chair with the feet upon the insulating stool; or if in bed, by placing the bedstead posts, or feet of the lounge, into thick glass salt cups. The patient thus situated can be *electrified positively* by connecting him with the prime conductor, or *negatively* by the rubber connection, by means of the long discharger, or by means of the chain, or by a large copper wire tipped with balls. By a steady and lively turning of the machine, the patient can be kept at this state for a half hour together, notwithstanding the continual insensible discharge that is constantly going on into the air. If in the dark, this phenomenon becomes visible, as the tips of the hairs and every other angle will appear luminous, or emit sparks even, if approached by a conductor to any part of the person.

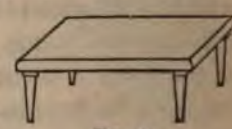


Fig. 39.

When a patient is insulated and gradually charged from the prime conductor *positively* to a high degree of tension, and thus continued for a little while, during this if any *pointed* director is placed near him, the plus electricity is by it drawn off at that vicinity very quietly, and almost insensibly, only giving rise to the phenomenon called *aura*. This acts as a *mild*, but most excellent local alterative stimulus; as, for instance, about the eyes and breast. But if we remove the *pointed* director, and in its place use a *ball*, then the electricity is drawn off from the patient in *sparks*, which produce a pricking sensation, much as if the skin were touched with a pin or needle; and the physiological result is also quite different. This succession of sparks produces much the same effect *locally* as the passage of a gentle voltaic current. The effect of these sparks (which can be made more seldom, long, and powerful, or rapid, short, and gentle, according as the brass ball is made to *approximate*, more or less, to the part) acts as a stimulus of a very peculiar kind; because, as Dr. Golding Bird says, besides the simple discharge, there probably is accumulated and *localized* in the flesh positive electricity, at and near the spot where the sparks leave the body, which is thus maintained in wavering density. The skin soon becomes red, which shows its effects on the capillary vessels and at the roots of the hairs. Drawing sparks from the back of a cat is easily done in dry, frosty weather, particularly if pussy is near the fire, simply by first smoothing her fur with a very warm and dry silk, then lightly stroking the fur in the wrong direction, when she will soon give you to understand that she does not like it. These sparks have an in-working at the moist roots of the hairs, and are of the very minutest quantity, but of the highest possible intensity.

It is well to know that in a room where the friction machine is being worked, every single object in that room is negatively electrified, if the rubber end of the machine is put in connection with the room by means of a trailing chain over the table and floor, instead of being in connection with the earth; and so can they become positively charged by reversing the order.

High-pressure steam can be so directed through crooked tubes

and friction on wood, as to produce a profusion of high tension electricity, that by far exceeds any friction electrical machine. We saw an apparatus both in London and in Paris made expressly for this purpose, called the *hydro-electric* machine. By this not only a patient, but a whole ward, patients and all, could be so situated and maintained by it for any requisite time. But according to my own experience, the utility of tension by insulation is quite limited to a few certain cases and conditions, which will be clearly designated when I come to treat of its therapeutic application for nervous diseases.

### *Galvanic Electricity and Apparatus.*

This term is given to that important form of electricity that is produced by *chemical action*. But probably the most simple example of this kind of electricity is shown by merely enclosing the tongue, for instance, between two different clean metals, from which the current is instantly set in motion, even sufficient to be sensible. This may be proved by any one, if they place a piece of silver or gold on the one side of the tongue, and then at the same time a piece of copper or zinc on the other side of the tongue, or, what is better still, simply a piece of clean zinc on the one side, while there is a piece of clean silver on the other. As long as the metals are so placed and held, there is no taste or sensation; but if now the outer edges of the two metals are brought together, or if by means of a bit of wire they are brought in contact or communication, then instantly there is demonstrated the galvanic action. If this does not readily appear at the first contact, repeat the opening and closing of the metallic contact quick or slow, and it will be decidedly manifested both by taste and sensation.

When two metals are placed in contact direct, or by means of a connecting wire, and when these are placed in a liquid or liquids capable of acting upon the one more than upon the other, then that peculiar electricity is evolved that we term *voltaic electricity*, *galvanic electricity*, or *galvanism*. The original *pile* for producing this current was devised by Dr. Volta, an

Italian physician, owing to the interpretation which this celebrated philosopher gave to the marvellous experiment of his contemporary, Dr. Luigi Galvani, of Bologna, namely, that a frog undergoes a violent agitation, when one of its nerves, being exposed, is touched with one metal, and at the same time its muscles are touched with another metal, while the two metals themselves are in contact.

Volta, and most natural philosophers since him, have supposed that the liberation of the current was entirely due to the *contact* of the two different kinds of metals, whilst the liquid between them plays merely the part of a conductor. To prove this, he invented his pile; and hence the term voltaic electricity. But it has since been proved by the researches of Sir Humphry Davy, M. Becquerel, M. De la Rive, and Professor Faraday, that the real source of the electricity is not from simple contact, but from the chemical action of two heterogeneous bodies; that contact is a condition most frequently necessary, but not always absolutely indispensable to the manifestation of electricity; that voltaic, or otherwise called galvanic electricity, may be produced by any chemical action; not only by the action of some liquid upon a solid, but likewise by the action of two or more dissimilar liquids upon each other; or even by gases acting upon gases, liquids, or solids. All agreed then, as now, that the effect produced upon the frog was due to the action of electricity; and as Galvani was the first discoverer of the phenomenon, this electricity is termed Galvanic, and the physical science concerned in it is called *Galvanism*. But to the pile itself, says De la Rive, must remain the name of its illustrious inventor.

*Voltaic Piles or Apparatus.* — All *moist* batteries, and the so-called "*dry batteries*" of every description, are termed *voltaic*, and provide only a primary current of electricity. Wet batteries are called *galvanic;* and from these two sources we derive all *primary* currents of electricity, which we term *galvanism* (in contradistinction to *faradaism*).

The original *Voltaic pile*, as first formed by Volta, was in the shape of a vertical column, formed of disks of copper and zinc of some two inches in diameter, and arranged as follows: —

A copper disk is first placed upon a glass, or some other insulating plate; a zinc disk is then placed directly upon the copper disk; and then the next disk is of cloth, well moistened with water, salt water, or acidulated water, which is then placed upon the zinc disk. A second similar pair is piled upon the first, a third upon the second, and so on to some fifty or a hundred pairs; each pair in the same exact order, i. e., first a copper and then a zinc, and each pair separated from the next pair by the wet cloth, and the whole retained in a pile by three or four perpendicular glass rods.

Fig. 40. Voltaic Pile.

This pile is found to be charged with negative electricity at its lower extremity, which is copper, and with positive electricity at its top, which is zinc. The top and bottom ends of this series or pile are called the *poles*. As soon as the poles of the pile are united by a conducting wire, the water that moistens the cloth between the several pairs becomes decomposed, and hydrogen is attracted to the copper, and the oxygen to the zinc. Then by this chemical action there is an electro-motive *force* set in action, which decomposes the natural or latent electricity of the metals into positive and negative electricity, the former accumulating upon the zinc pole in this arrangement, and the latter upon the copper. This pile may be laid down, or turned the other end up, — still is the zinc the positive pole, and the copper the negative. But here let me call particular attention to the *fact*, that this is exactly the *reverse* of what obtains in all our metallic pairs in liquid batteries, — for then the copper is the positive, while the zinc is the negative pole; but this can be easily explained. From this fact not being *heeded* a deal of confusion and misunderstanding has always resulted. The batteries with which we have to do, then, give the most oxidizable metal, which is zinc, as the negative pole; while the least oxidizable metal, which is copper, or silver, or platinum, is the positive pole; but in a moist or dry pile, the reverse is the result. Let these facts be retained.

The *Dry pile* is constructed much as Volta's original moist pile; but it is not an absolutely dry pile after all, for in that case it would not act. To prepare the permanent dry pile, large, stout sheets of brown paper are coated on the one side with tin foil, which answers to the place of the zinc in other batteries, and the other side of the paper is coated with the peroxide of manganese, which answers to copper. The paper is first tinned on one side only; on the other side the manganese is spread by means of a soft brush. The powder of peroxide of manganese is prepared in a fluid paste and milk. When the sheets are dry they are cut neatly in squares for disks. These are then laid in the same order, the one above the other, so that a face of tin and another of manganese may always be in contact in all the layers; while between every pair, or two such leaves, there may also be placed a blank sheet of the paper, and thus hundreds, or even thousands, may be built up to compose the dry pile. But the paper evidently gathers a minutia of moisture from the atmosphere, and this is the acting agent. This pile, being built upon an insulator, terminates at its top and bottom with the opposite kinds of metals; the tin is the negative pole, while the manganese is the positive pole. This pile cannot yield any very appreciable current, and yet it will for years give small sparks between its poles at any time. This shows its peculiar polarity, or tendency to *accumulate* tension electricity at its extremities or poles.

But to return. If the two poles of the voltaic pile be connected by a conducting wire, then the two opposite electricities travel towards each other over the same wire to neutralize where they started from, which is at the zinc or most oxidizable metal. But as there is a certain continuous supply, there will also be a continuous process or *current* as long and in proportion as the chemical action continues. Hence it results that *the power of this pile is variable;* it begins to diminish from the moment it is laid up, and in a short time it totally ceases, — the copper disks having been covered with hydrogen together with oxide of zinc, from the decomposition of sulphate zinc, while the zinc disks are also loaded with their own oxide. This was

a great inconvenience; besides, it gave the widest variety of results.

To avoid this trouble it was proposed to substitute for these disks a *trough* of liquid; and this necessarily converted the arrangement into a horizontal succession, instead of a perpendicular pile. The disks or plates were then to be rectangular, in the place of being circular; each two dissimilar metal pairs were to be in contact, and the whole series to be wedged tightly in the wooden trough, and so adjusted that they formed *cells*, and could be filled with the acidulated water in the trough at pleasure. This improvement was first pointed out by M. Cruikshank, and was then arranged for and given by the Emperor Napoleon to the great Polytechnic School of France. It was with this battery that MM. Gay-Lussac and Thénard, in 1808, made their splendid experiments; yet this cell trough was almost as troublesome as the original pile, but it possessed the advantage of more uniform and greater power *when cleaned* and put together anew for work.

### *Galvanic Batteries.*

*Galvanic* or Voltaic Apparatus, from which alone we must obtain the *primary* current of electricity, suitable for medical and surgical purposes, should possess the following indispensable or desirable qualities, — all of which, however, I have never found in any one simple arrangement: —

*First, there must be uniformity of action;* i. e., the battery must continue to work at about the same given rate, at least during the office hours of a day; and if it runs thus reliably for weeks or months together, and keeps in order, all the better.

*Second*, there should be produced a very *large quantity* of electricity, *without intensity*, as when required for cauterization.

*Third*, there should be provided both large *quantity and intensity*, as when needed for electrolysis and catalysis; i. e., for chemical effects in the tissues; as through ill-nourished, atrophied, and degenerated muscles; for dropsical joints; for gouty and rheumatic callosities; and for changing the polarity of large nerve-trunks.

*Fourth*, a primary *intense* current is required; such, for instance, as can be temporarily produced by a new and full Pulvermacher chain, for reflex action, and for a certain class of neuralgias.

*Fifth*, for healing old ulcers; for restoring nervous and nutritive processes, as in many cold or lifeless limbs; for toning the sphincter ani and the cervix uteri; also, for allaying morbid irritability in those parts, by a reversed arrangement, a *small quantity*, with still less intensity, is all that is requisite.

Whether from one machine or many, the required current should be handy, reliable, and controllable. That is, the dose of primary electricity to be employed, when used directly as such, should be easily and accurately graduated and measured, without the necessity of depending upon the impressions of the patient, which must be variable in different cases, and hence entirely unreliable. At the same time, it is equally important to be attentive to the effects produced, and to learn of the patient also the kind of sensation or degree of impression or suffering, if any at all, that may result.

Engaged constantly in this special practice, the author has found it practicable to keep in ceaseless action and readiness, during many years, a variety of these sources of true primary galvanism. By means of the key-board we are also able to bid up any amount of intensity or quantity, or both these qualities of electricity, from one element to one hundred and thirty, arranged in three different series and sizes, for meeting a wide range of indications. But the most of such apparatus is ponderous, and suitable only for office or hospital use. The general practitioner, requiring portableness, must be content with such compact, durable, and clean arrangement as he can best command, to meet the greatest needed indications. For this end I arranged the "*Petit*" *battery*, as manufactured by T. Hall, 15 Bromfield Street, Boston. It is not a primary battery, but it yields only a *one-way* current, the *extra current* of chemical action; and is very portable, powerful, and penetrating. But some physicians prefer the portable *constant battery* of T. Hall, Boston; or the improved vibrator and helix *Smee battery* of

J. Kidder, New York. Some of these, or other good faradaic to-and-fro apparatus, must generally make up his electro-medical armamentarium.

*Cruikshank's battery* was then improved in various ways, until the cells of the trough were made to receive two plates of dissimilar metals, as before, it is true, but not of the same pair; i. e., one plate of a pair was in one cell, while the other plate was in the next cell, yet so as to be lifted out or put in, so that every cell received a pair of copper and zinc in the same liquid, not in metallic contact between themselves, as in the original, but connecting only with its next neighbor. This is the true arrangement of a galvanic battery as first shown by Becquerel. The author saw the remains of such a battery, which was provided for Sir H. Davy, in the laboratory of the Museum building of the Royal College of Physicians and Surgeons in London. Although only some eight or ten cells were in each trough, yet such a number of these were provided in connection, as to give him a battery of some two thousand pairs. It was with such ample means that Davy, and, still more recently, Faraday, made their splendid discoveries.

Dr. Wollaston found that the effect of this battery was still further augmented in power, for the same number of cells, if there was a greater surface given to the copper than to the zinc. This double-sized copper characterized the Wollaston battery.

*Berzelius* then demonstrated that if, instead of using a wooden trough, the copper itself be made into cells, or cups, so as to hold and envelop the zincs, but without touching, this would enhance still further the excellency of the battery. Such galvanic arrangements were for many years exclusively used for all experiments and practice that was ventured upon; but they all possessed one great inconvenience; and that was, that after a very *short* time they lost their power, and finally would cease to act, until they were cleaned and replenished.

Fig. 41. A Berzelius Battery, separate from the Induction Helix, — commonly called the "Copper and Zinc," or Sulphate of Copper Battery.

To avoid this, M. Becquerel proposed to plunge *each* of the metals into a *special* liquid, — being separated from each other by a porous diaphragm which would conduct and allow a communication between the two liquids. To that end he constructed a battery in a glass jar; he then placed in this vessel a cylinder of zinc, closed at its bottom like a deep cup. In the space between the glass jar and its contained zinc cylinder he placed the acidulated water; but in the interior of the zinc was placed a bladder, or piece of intestine, which contained the copper, together with a strong solution of the sulphate of copper. When the poles of this battery are connected, both the water and the solution of sulphate of copper are decomposed by the electro-chemical action; one part of the oxygen liberated combines with zinc to form oxide of zinc, which at once combines again with the sulphuric acid that acidulated the outer fluid to form sulphate of zinc, while another part of the oxygen combines with hydrogen to form water. Besides this, there is a thin film of copper deposited on the surface of the within copper. Now, it is easy to see that Becquerel's battery would work more slowly, but far more constantly than the voltaic pile or any other battery then known. But the organic membrane was not, after all, very durable; and this was the greatest objection to this otherwise valuable battery.

The *Water battery*, as it is called, came next. It was first prepared by M. Gassiot, and is peculiar for possessing properties of but feeble dynamic electricity, as compared with its static accumulation and tension effects. This is indeed the characteristic also of all so called *dry piles*, which give an electricity in a state of tension alone. M. Gassiot employed glass cells, which were supported upon glass columns so as to render the insulation more complete. Thus he constructed a compound battery of 3520 zinc and copper pairs in as many cells, which were charged only by pure water. This, says M. De la Rive, during the several years it has remained set up, at all times gives electric sparks at each of its poles, (which are also insulated.) The only precaution taken with this apparatus, is to pour water into the cells occasionally, so as to replace that which is lost by

evaporation. In this case, it is the air that is contained in the water that oxidizes the plates so slowly or minutely, that it thus lasts and acts for years together.

In 1836, Daniell conceived the idea of trying various durable partitions to separate the two liquids, as Becquerel had been trying to do. He placed the copper of each pair in a solution of the sulphate of copper, which occupied the larger outer space in the jar, while the zinc was placed in a solution of salt and water, or acidulated water — say sulphuric acid one part, to water twenty parts, or in sea water. He made some diaphragms with felt, some of stout paper, others of very thin wood. Experience gives the preference for a kind of porous *porcelain*, that is durable and yet slowly transmits the liquids for action upon the metals.

In the inner cell, then, — that is, within the porous cell, — he places the zinc in a solution of salt and water, or acidulated water; but the zinc is first coated with quicksilver, which prevents its being attacked *while the poles are not* united by a conductor, and so without diminishing the effect of the battery *while not in use*. But it will be perceived that the decomposition that is brought about is the same as in Becquerel's.

Fig. 42. A Series of three Daniell's Batteries for Galvanism, showing their Connections.

*Daniell's battery* is now so improved that it is the most permanent and even-working galvanic battery known, and for medical purposes it is invaluable, particularly for the so-called *constant galvanic current*. The arrangement is in large, strong quart glass jars, by using porous diaphragms of pipe-clay cups. Within this porous cup is the solid pound of zinc, say an inch or so in diameter and some four inches long. Then a bit of

sheet copper, say four by six inches, is so rolled and bent as to just drop inside the glass jar, and the jar is then packed nearly full of crystals of sulphate of copper. Indeed, it is better to bruise the sulphate a little in a mortar, so as to work it in without getting it also inside of the pipe-clay cup. The copper is thus buried in the sulphate, and the zinc is placed within the pipe clay; then the whole is filled to within a half inch or so of the top of the porous cup with water. It is better not to fill the inner cup quite as full of water as the outside of it is, for this will allow the battery to get at work within a few hours. Some thirty to fifty of these cups connected *consecutively* form a battery sufficiently powerful for any remedial purposes, and yet, if well managed, will run for a half year in good working order without replenishing except with water. In fitting up this battery, I find it very advantageous to place a strip of stout brown paper or *oil-cloth* about the tops of all the cups, *to prevent* the capillary attraction in the re-crystallization of the sulphate driven on by the process, from running over the outside of the glasses. This has caused me a deal of trouble, as, in the course of every few months, we would find great quantities of the copper solution crystallized all over and between the glass cups; but by pasting strips of rubber cloth tightly and carefully around the tops of the cups, so as to be some half inch above them, it will stop it; (for these cups are without lips or rims,) and then the paper should be varnished on the outside. This appears to be the most effectual means I can find to prevent this dirty and wasteful inconvenience.

Fig. 43. A Series of Grove's Batteries in a Box, 12 in number.

The next improvement made in the galvanic battery was by Grove; and his is one of the most *powerful* that has ever been constructed. In this battery a small plate of platinum takes the place of the copper, and a strong solution of nitric acid is used in the place of the solution of sulphate of copper. The amalgamated zinc is plunged into a strong solution of sulphuric acid, which is contained within the inner cup of unglazed or porous porcelain. The zinc is amalgamated, or covered with a coat of mercury, by dipping it into a vessel containing a strong solution of sulphuric acid with quicksilver, or by pouring these on the plate, and then brushing it with a tooth brush until amalgamated. Thus the surface of the zinc is cleared by the acid, when the mercury will readily adhere and coat it. In this arranged battery, the nitric acid has the double advantage of containing much oxygen, which first increases the intensity of the current; and second, being a better conductor than the solution of sulphate of copper, it transmits the current through the batteries more readily. Here the hydrogen is not developed upon the platinum, but changes the nitric acid into nitrous acid, and the liquid therefore becomes of a brown color, and then soon passes into a green color, while the surface of the platinum always remains the same — that is, clean. The zinc is oxidized, and sulphate of zinc is found in solution. But after a certain time, this furious battery is fairly *self-arrested* by the further changes which are going on so rapidly in the nitric acid, resulting from the development of hydrogen and heat, until the acid actually enters into ebullition at last, and like the back water of the flooded milldam stops action because there is so much action. In this stage, it is absolutely necessary to stop the action immediately; i. e., to take it apart in order to save the battery.

*Bunsen's battery* is another powerful apparatus for particular purposes, and this differs but little from Grove's, only as *carbon* is substituted for platinum. It was formerly found that platinum was more negative than copper, that is, still less attacked by the liquid; so is carbon still more negative than even platinum, besides being very much cheaper. In the original Bunsen's battery, there was arranged a cylinder of baked carbon,

*open* at its bottom and placed in the glass jar, within which was a porous diaphragm of pipe clay, which contained the zinc and dilute sulphuric acid, while dilute nitric acid filled the jar about this large body of carbon. But this has lately been improved, so as to dispense with the porous diaphragm altogether. The author has seen some of these improved *carbon cups*, with *closed* bottoms, so prepared by T. Hall, for the professor of chemistry at Harvard. Some five or six cups produced a heating, chemical, and decomposing power, equal to fifty cells of best Cruikshank's. In this case the carbon cup is fitted with dry powdered carbon, and moistened with nitric acid. We formerly used this battery for cauterizing, as it possesses the most tremendous *quantity* power; but it does not last very long in action, nor is it required to act long for such purposes.

*Grenet's battery*, for surgeons' use, is here illustrated by Fig. 44, and it is truly a wonderful *multum-in-parvo* instrument for generating and maintaining electric heat. Indeed, this battery is made expressly for this purpose. It yields only *quantity* electricity. The cut shows its structure and appearance when out of its bath. It is composed of some six carbon plates, and eight plates of hammered zinc, amalgamated with quicksilver; each of which is about six inches square, and adjusted exceedingly close together in a frame-work of hard rubber; all the zincs being connected as one folded plate, and all the carbons are likewise connected together as one. Hence it acts as but one grand element.

Fig. 44.

A hard-wood box, lined with sheet lead, and having some three gallons' capacity, is provided to receive it. Into this bath-box we pour six quarts of water, and add two pounds of clear sulphuric acid, free from black or straws, and while stirring the water with a strip of glass, pour in the acid gradually. Then add one pound of bichromate of potassa, a good article, coarsely pulverized. Stir well until dissolved and cooled. When all ready for the operation of cauterization, the conductors and the chosen cauterizer being already selected and adjusted, the battery is to be lifted gently into the bichromate solution, and the instant contact is made, the cauterizer becomes brilliantly red-hot. I regulate the degree of heat by screwing fast only one of the conductors, merely holding the other in contact, so as to quickly remove it if necessary, or more lightly touching it to the binding-screw. As soon as the operation is over — whether five, ten, or thirty minutes — the battery should be taken out of the bath, and immediately rinsed with clear water. It is also well to pour some quicksilver over the zinc plates after each time of using. The solution is to be left in the lead-lined box for future occasions.

After this battery has thus been used a few times, the produced heat is less. In this case, or if a more severe operation is anticipated, fix on the elastic tubes and adjust the bellows, so that an assistant can force air to the bottom of the battery, which is perforated from an air-chamber. The air is thus forced down, and up through the solution, aerating it and causing a more rapid oxidation. Thus any degree of heat, even a white heat, may be obtained, regulated and maintained for a good part of an hour. The battery is then readily cleansed, as above directed, and the solution is to be renewed when exhausted. Phile Grenet, 14 Rue Castiglione, Paris, provides this beautiful apparatus, as also a smaller one for faradaic currents.

*Thomson's constant copper-carbon battery* is intended to be an improvement on Daniell's and Smee's batteries, as *a permanent primary compound battery*. It is called "*the copper-carbon element*." Usually zinc officiates as a positive element. In the Thomson's battery, *copper* takes the place of zinc, which is placed in dilute sulphuric acid (one part to four of water) as

a positive element; and as a negative element, *carbon* is used, in a mixture of bichromate of potassa, sulphuric acid, and water,—twelve parts of bichromate, twenty-five of sulphuric acid, and one hundred parts of water. The electro-motive force of this battery is nine tenths that of Daniell's improved battery. The copper is not the least attacked when the circuit is open; the resistance of the sulphuric acid is minimum, being so little diluted, and yet can be used for months without being saturated, i. e., spoiled, while the mixture of bichromate and acid is inodorous. This combination is very convenient for permanent use in close rooms.

*Smee's battery* is the most clean, and one of the most permanent and economical arrangements we know of. This is arranged in a quart or half-gallon glass jar, by mostly filling it with water acidulated by one tenth or one fifteenth part of sulphuric acid. Into this are plunged two flat, square plates of zinc, say four by six inches, and one half inch thick, and coated with mercury, which are suspended from the top. Between these there is arranged the thin plate of platinum or platinized silver. This apparatus can remain in working order for a month, but if much used should be overhauled once a week; that is, the zinc plate should be new coated with quicksilver, and if that is well attended to, for dentists and other office use it will wear a year or more.

Fig. 45.
Smee's Constant Battery.

Fig. 46 is a view of *Humboldt's battery*, consisting of one primary element. This is something new, although the *principle of its action* was known to the great baron and philosopher nearly seventy years ago; but the term *Humboldt's battery* originates with the author. The convenience and usefulness of this very cheap, portable, durable, *and least troublesome of all gal-*

Fig. 46.

*vanic arrangements*, and its very peculiar adaptation, under frequently recurring circumstances, for the treatment of a given class of cases, must gain for it a prominent place among the more *practical and reliable* of our best electro-therapeutics.

Fig. 47.

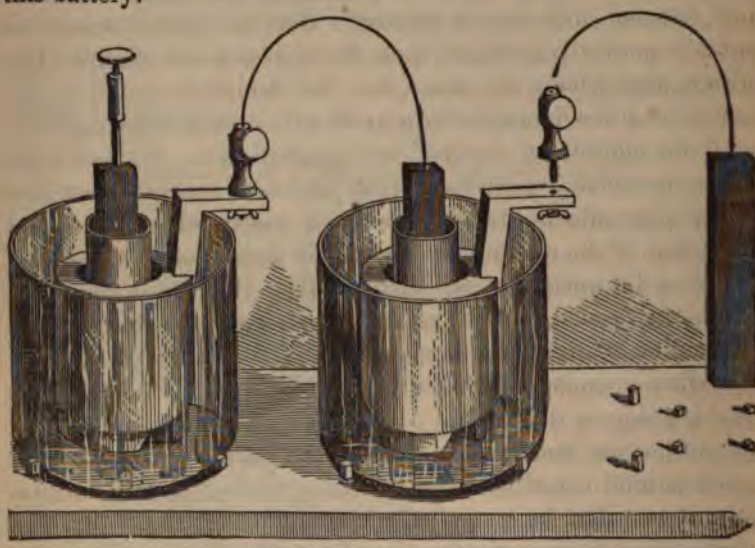
Fig. 47 is a view of *Pulvermacher's portable chain battery*, for medical purposes; consisting of 1, 10, 25, 50, or 100 adjustable elements. It is better known in Europe, and is a very remarkable miniature voltaic pile. The *pairs* of this consist simply of a piece of hard wood, around which is coiled a zinc wire, that terminates at one end with a hook or eye. Then there is coiled between the zinc coils a brass wire that terminates at the other end of the link in the same manner. This forms an element. These are linked together like a chain, the brass end of one into the zinc end of the next, and so on for sixty or one hundred and twenty links, which terminate with a brass buckle and belt at one end, and a silver plated buckle at the other, for fastening it about the body or limb; or, according to Pulvermacher's directions, "Apply the gold buckle over the spine, and the silver buckle over the seat of disease." Besides, there is a clock-work for breaking the current, &c. But this voltaic principle, for economy, correct as it certainly is, becomes a failure in practice — first, because of its frail construction; second, because of its electrode arrangements being intended for empirical application, rather than for scientific and skilful manipulation.

The *Electric Moxa* of Dr. Golding Bird is admirably made by the Humboldt battery, heretofore described. He advised the making of two blisters, by blister-plaster, in the ordinary way; the one above, the other below, the spot that is to be affected.

The silver plate is to be placed upon the *lower* denuded blister, while the zinc plate is planted also over the upper denuded blister, when the connecting wires from each are brought together, and twisted into secure contact. But the joined conductor must be perfectly insulated from the skin and wet cloths. The blister, over which the zinc plate was bound, is found, in the course of a few hours, to be coated with a whitish-looking film, as if the chloride of zinc had been applied to it. In forty-eight hours an eschar is produced, which begins to separate some four or five days afterwards. The eschar is produced by the chemical action of the continuous current in decomposing the effused fluids on the surface of the blister. The chloride of zinc thus gradually formed, and as gradually applied, by the electro-chemical action, produces the new sore that will now freely discharge pus when a common poultice is applied to it. While this process is going on the patient is *usually* quite free from pain, but the author has known some decided exceptions. Where it does prove painful it had better be at once removed, for after a little time it can often be reapplied without the suffering. Dr. Bird advises the blisters to be the size of a half dollar or dollar, and to always apply the *zinc plate* (which is of the same size of the blister) *nearest to the head of the patient*, while the silver, which is the same size, is *farthest* from the head, and nearest the extent of the extremity, as, for instance, of the hand or foot. Over each plate, water or salt-and-water dressing is applied, and, above this, oiled silk or rubber cloth, merely for the purpose of retaining the moisture; while flannel or warm clothing covers over the whole.

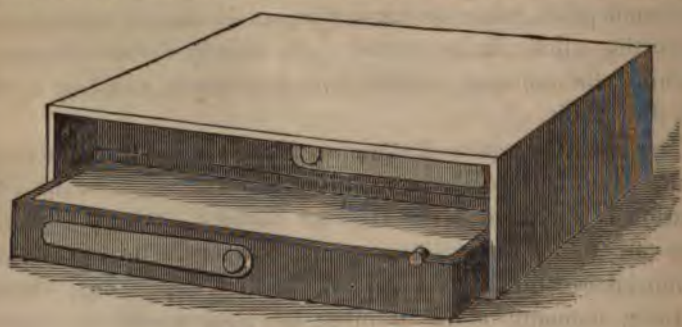
*Chester's Electropion Battery.* — This is a new permanent galvanic battery. It will act a month or two without renewing. The solution is the same as for Grenet's battery. (See p. 328.) It gives out no deleterious fumes, is less expensive in the end, and far more powerful than the Daniell's battery, cup for cup. Twenty or thirty elements of his number *two* cups would be equal to twice the number of a Daniell's battery, and quite sufficient for medical office use. This battery yields *great quantity*, with little intensity, and is of late my favorite battery *for the treatment of pro-*

*found nervous diseases.* It can be had of Chester & Co., 104 Centre Street, New York. They supply the electropion solution for this battery.



Chester's Electropion Battery.

*Chester's Dry Voltaic Battery.* — This is compact and dry, and small enough to be carried in the pocket. It is made up of carbon plates, with *platina* connections, and zincs, with thin cloth inter-



Chester's Dry Voltaic Battery.

posed. They are charged by spreading over the carbon a little deuto-sulphate of mercury moistened with water. It is strong enough to charge the helix of a medical instrument.

Electrodes, platinum points, needles, and cauterizers for surgeons' purposes, can be had of electrical instrument makers: T. Hall, 15 Bromfield Street, or Codman & Shurtleff, 13 Tremont Street, Boston; or of Chester & Co., 104 Centre Street, or Tieman & Co., New York; and of surgical instrument dealers in Philadelphia, and elsewhere.

### *Static Electricity as it relates to Medicine.*

We now know that we cannot classify all bodies into *perfect conductors* of electricity, and into *perfect insulators;* or, in other words, we cannot say of silk or metal, that the one never conducts in any case, or that the other conducts perfectly well under all circumstances; therefore the *term* electric conductibility is not absolute. The metals are almost perfect conductors; yet they present among themselves, as we have already observed, a difference in degree of conductibility; also the same metal or body conducts better or worse, according to its *dimensions* and its *temperature*.

*Generally* we call all bodies *electrized*, whatever they may be, which have been put into communication with an electrized body; but strictly so speaking only when they thus show an attraction at a distance upon light bodies. Therefore in Static Electricity we are taught to observe,—

1. That there is an *attraction* between an electrized body and one that is not electrized.

2. That there is *repulsion* between two bodies electrized by the same source of electricity.

3. That there is an *attraction* between two bodies electrized, the one as by glass, and the other as by wax; glass acquiring by friction *vitreous* electricity; wax acquiring by friction *resinous* electricity; the former, or vitreous, is termed *positive electricity;* the latter, or resinous, is termed *negative electricity*. When these reunite, and neutralize, either through the air as a spark, or insensibly, or through a conductor, the electricity is then said to be in the *dynamic state;* i. e., during the *instant* that this marriage is going on. This is also termed the *electric discharge*.

To be understood, this denomination of *dynamic* is given to that state of movement in which the two electricities are supposed to be, when travelling towards each other to neutralize, in contradistinction to the *static* state, or that of rest, as where these two different electricities are found when they are separately accumulated, on insulated bodies. This latter state is also called *electric tension.*

We see, then, that dynamic electricity may be only *instantaneous*, or it may be *continuous.* In the preceding case it was instantaneous, and done. But suppose one ball to be in communication with a constant source of positive electricity, while the other ball is connected with an equally constant source of negative electricity; the two electricities being constantly renewed as fast as they are neutralized, there will be a continuous succession of sparks, if the balls or electrodes are brought only close together; but if so as to touch each other, then there will be between the two ball electrodes a continual, uninterrupted neutralization, or, in other words, a continuous reunion of the two electricities. This is denominated *the continuous dynamic state*, and also called the *electric current.*

### *Electric Conduction.*

The property which is possessed by most bodies, and by metals in particular, of more or less readily acquiring and propagating through their whole extent the electricity that is possessed by that part of an electrized body with which they are in contact, is termed *electric conduction*, and such materials are called *conductors.* Those which do not possess this property are called *insulators.* The human body, ordinary wood, animals, vegetables, and most minerals are conductors; while amber, wax, glass, baked hard wood, fur, gum-lac, resins, and a majority of crystals, as also silk, oil, rubber, and gutta percha are *non-conductors*, or, in other words, are insulators. The earth is our largest conductor; the vast extent of atmospheric air over its surface, when dry, is our largest insulator. The *diamond* is the most perfect insulator, while *silver* is most nearly a perfect conductor.

The conductibility of bodies for electricity, which are so reckoned, is not, however, an absolute property, for there is every grade of difference observed in different bodies; and these even vary in themselves at different times. Water is a conductor, but *dry* ice is a good insulator. Glass is reckoned a most excellent insulator; but if it is damp, or is drawn out into a slim rod, or is heated to redness, it becomes a good conductor. Wax and tallow become conductors by melting them; but the metals, on the contrary, *do not* conduct so well when they are heated.

The dry atmospheric air, being an insulator, prevents electrized bodies losing their electricity. Were the air a conductor, it would cause the electricity of every insulating body to be dissipated into the whole mass of the atmosphere, as does contact with the earth. This does take place when the air is moist, or where the apparatus is colder than the air. Therefore it is necessary to have a dry atmosphere, and a machine free from humidity, to make experiments or practice succeed well with friction electricity.

It is necessary to be mindful, that, if any electric current of a given quantity and intensity is made to pass through several different wires, of the same sample of metal and make, and same diameter, but of different lengths, we shall see that the current loses power in proportion to the length of the wires tested. If, now, the current is made to pass through wires of exactly the same metal and length, but of *different diameter*, the power is greater in proportion to the diameter of the wires. For instance, a copper wire that is a hundred feet long and the tenth of an inch in diameter, will offer the same amount of resistance as another copper wire that is two hundred feet in length and only one fifth of an inch in diameter. The conductibility of bodies, therefore, does not depend upon their chemical nature only, but also upon their *form*. Nor are there any absolutely perfect conductors of electricity. Indeed, it may be said that *all bodies* through which a current may be directed offer a certain greater or less resistance; and hence diminish its intensity according to their chemical nature and form.

If a galvanometer be placed between the shortest poles of a

voltaic battery, we see the astatic needle deflected to a certain degree by the passing current. If we now lengthen the conductors by interposing copper or even silver wire of a given length, and then again of twice that length, and then again of twice the length of the latter, we shall find from these experiments, that the needle of the instrument is less and less deflected, according to the length of the conductors, although of the very best material. The human living body conducts all electric currents ten to twenty times better than pure cold water. This is supposed to be on account of the warm salt water it contains. But I am more and more inclined to believe that this is owing to the arrangement of these different fluids in the different cells and tissues of the living organism, which are separated only by the thinnest membrane, and being provided with nerves, not only have a *tendency* to electric action, but possessing an *actual, perpetual* minute action, which, to my mind, serves for the artificial current conduction, much as Professor Morse's registering battery helps the working of the wires; perhaps more, as the aurora borealis helps the conductibility of the telegraph wires.

The epidermis is, in this case, probably, the greatest hinderance to all currents of electricity; but this can be greatly counterbalanced by *wet* electrodes. There is an absolute difference in the conductibility of different persons, and even of the same individual at different times. In a group of persons, a single one may be struck by lightning, while all the others remain untouched. But this is not as yet satisfactorily explained. The human body, then, after all, is not in effect a good conductor of electricity, as can be proved by the galvanometer. To test this, the resistance is first determined of the given entire circuit, of say a bearable, but appreciable battery, such as twenty to thirty Daniell's elements afford, by bringing together the two poles in good contact, including nothing but the galvanometer. The degree of resistance from the connecting wires of the batteries, the conductors, and the instrument together, as marked on the dial, is first noticed, and taken for unit or zero. Then the limb or individual is interposed between the wet electrodes, which

must have large and complete contact. Let this be repeated first without, and then with the interposition of the portion of body to be tested, and a very exact relative degree is obtained of the resistance of that given organism.

### *Direction of the Current.*

In the original *voltaic pile*, the positive pole, we have seen, is at the top of the pile, which is zinc; while the bottom of that pile is consequently positive, which is copper. This *law* holds good with all dry, or moist, piles and batteries; as by the law of electro-motive force, positive electricity is driven from the copper to the zinc, and hence the zinc is forced to be positive and the copper negative. *But, mark — this is not true* of our ordinary liquid batteries; for where the metals are plunged into separate vessels, as is the case in the constant batteries, the direction of the current is exactly the reverse. In these batteries, *the positive current travels from the zinc* through the liquid of the battery to the copper, and then from the copper to the zinc of the next pair, and then through that liquid to the copper there contained, and so on through all the series of pairs in the cups or jars of the compound battery; so that the copper is always the positive pole in these constant batteries, and the zinc of course is the negative pole. This is even so in a Berzelius's or a Smee's battery, where there is a single pair in a single liquid. Therefore, in the Berzelius's and Daniell's batteries, the positive pole will be formed by the copper; in Grove's or Smee's batteries, by the platinum or silver; in Bunsen's battery by the carbon; while the zincs form the *negative pole* in each and all of these batteries.

To fully appreciate the kind, nature, and difference of battery or chemical electricity, and to have a rational view of these currents, we must set out with this *law*, namely: where a liquid attacks a metal, the liquid becomes charged with *positive* electricity, and the attacked metal becomes *negative*. The positive of the fluid is at once taken and conducted by the less oxidizable metal that is plunged in the same, and thus conveyed along the conducting wire, back to the oxidizing negative plate in the

battery. If a vessel is nearly filled with acidulated water, and into it we plunge a plate of very oxidizable metal, such as zinc, for example, and also another plate that is much less oxidizable in that liquid, as platinum, and then we unite the two dissimilar metals merely by means of a wire brought up out of the liquid, then the positive electricity that is acquired by the liquid, from the effect of the chemical action, is able, by traversing the connecting and conducting wire, to return and reunite with the negative electricity that the attacked metal has retained. For thus the greater portion of the two electricities, negative and positive, become neutralized through this peculiar process and order, instead of taking place locally, directly at the place of contact of the liquid with the metal that is oxidized, and which Faraday has termed *local action*. Here, then, we see the *rationale* of the electric current or *stream* of the battery with which we shall have so much to do. And this peculiar association or relation of any two dissimilar metals in a liquid, whose power for oxidization and conduction is peculiarly or exclusively for one of the metals rather than for the other, is termed a galvanic pair or battery; and when a number of these are connected, they are then termed a *pile*, or so many *elements*, or a "*compound battery*."

Philosophers teach us that we may also regard the two metals of any voltaic or galvanic pair as separately, but mutually, giving rise to two opposite and unequal currents, one of which — and it is always that arising from the metal most attacked — is the more intense, while the other, arising from the metal least attacked, is the more feeble; that each of the two metals also serves as a conductor to the current of the other. The current, then, that is accumulated is the difference between the two partial and unequal currents, as they would be perfectly null if these two opposite and simultaneous currents were absolutely equal — a condition, as M. De la Rive says, next to an impossibility, even if we employ two metal plates as similar as can be in every respect.

It is, therefore, a *law that the metal of the battery that is most attacked determines that current direction*. But while we attempt to establish in our minds the *first fact*, that the

metal most attacked is the *positive*, and the *second fact*, that the metal least attacked is the *negative*, we must not lose sight of the *third fact*, that the positive electricity comes out of the battery by the negative or copper metal after having passed through the liquid of the battery, and consequently the other, or *negative* electricity, comes out by the positive or zinc metal, so that in these batteries the *zinc pole is negative* while the *copper pole is positive*. Besides, we should take the terms *positive* and *negative* simply in the sense of *electro-motive power*, — the positive as predominating over the negative, and constituting a prevailing stream or current. But we must also recollect, that although it is true that the metal most attacked is the starting point for the current direction, yet the mere galvanic series of metals do not of themselves and under all circumstances determine the route of the current *absolute;* for this is likewise dependent upon the *nature of the liquid* that is employed as an exciter or oxidizer. Faraday found a very curious and interesting *variation* of the current when he placed a galvanic pair of copper and silver in a solution of sulphuret of potassium; the current first setting out from the copper, the silver is not the least tarnished, and soon the action dies down to a low degree. But this is soon seen to be followed by an increasing action that is now on the silver, which gives rise to a current running in the opposite direction, while the silver is becoming more and more coated with the sulphuret; and at the same time the film that was at first formed on the copper is as rapidly dissolved off; in a few minutes more and the needle of the galvanometer drops to near zero, but as soon again begins to rise, reversed, showing an increasing but changed current direction, and the copper again becomes positive, and coats over. Thus the chemical action and the direction of the current change simultaneously.

### *Quantity and Intensity.*

Electricity, when in the current form, has two very distinctive and important characteristics, which must never be unheeded or

confounded. I refer to *quantity* and *intensity*. There appears to be no actual relation between the vivacity of chemical action and the preponderating intensity of electric signs. From this it does not follow that the *quantity* of electricity that is set free is not in relation to the given chemical action. On the contrary, these two respective quantities are in exact proportion to each other. Then it is rather the *nature* of the chemical action than the vivacity of it that determines the characteristic of *intensity* in the given electric manifestation. There cannot be intensity, however, without some degree of chemical action; but the amount of such action graduates the amount of electricity: because this kind of electricity possesses the characteristic property and power of overcoming a great resistance, it was therefore first termed by Faraday electricity of intensity, in contradistinction to electricity of quantity.

These two different forms of electricity from the various galvanic pairs have very different physiological effects, and therefore require to be particularly observed in all therapeutic employments of the current. How, then, can this intensity of the galvanic current be reënforced without a corresponding increase in the quantity? One way to do this is by simply *adding similar pairs in succession, and so connecting them that the positive of one is in metallic contact with the negative of the next*, and so on through all the series, no matter how small or great the number. M. Gassiot, by a series of most remarkable researches with his *water battery* of 3520 galvanic pairs insulated, discovered in this connection, that the more powerful the mutual affinity of the elements that compose each battery, the less number of such are required to produce the same great effects of tension. He found, by well insulating one hundred of Grove's batteries, a *tension* accumulated at the poles quite equal to that of the whole water pile of 3520 pairs. But to test the *relative* tension of such an arrangement, that is, with the same given deviation of the galvanometer, it is necessary to use the electrometer to detect directly the tension, or by using the rheostat to detect the amount of resistance that is overcome.

The law of electro-chemical equivalents of a single galvanic

pair was first pointed out by Faraday. M. Matteucci next gave the equivalents for a pile or series of batteries, by using as a good electrolite a solution of the sulphate of copper. If the battery, for example, is composed of ten cups and pairs, then ten equivalents of zinc must be consumed to decompose one equivalent of water — thirty where there are thirty cups, and so on. It would seem, then, to be much better to employ only one or two cups and pairs, since to produce the same effects, where no great resistance is to be overcome, we can save some ten to thirty parts of zinc. But we find that the decomposition is less free, and also the electrolite *requires* a current possessing a certain degree of intensity, or, what amounts to the same thing, having an electro-motive *force* of a certain power, which can best be given it by multiplying the number of cups. So, also, as regards great resistances that are to be surmounted; M. De la Rive says, "When a current is called upon to traverse a long telegraph wire, it is necessary for it to be accomplished to use a numerous succession of cups, for if it were attempted to be produced by only one or two cups and pairs, no matter how great their size and power, it would not have sufficient *intensity* to overcome the resistance of the long wire."

We must also be reminded, that the *size* of surface of the galvanic pair or pairs is able to influence *only the quantity* of chemical action exerted in a given time; but that it can in no way modify the electro-motive *force* of the pair or pairs, nor will there be the capability of the produced electricity for surmounting a given resistance; for where this resistance exceeds a certain bound, itself limits the quantity of efficacious chemical, or catalytical action, by the very deficient quantity of electricity that can be transmitted in a given time, and hence renders useless the increased surface of the plates beyond a certain size, which is in relation to that of the resistance and kind of work to be done. The *quantity* of the current is in proportion to the *size* of the pair; the *intensity* of a given current is in proportion to the *number* of pairs.

On the whole, then, we see that the law of electro-chemical action, as far as it concerns the electrolysis placed in the given

circuit, exterior to the series of pairs, i. e., placed between the poles, is a *general law*, and applies therefore equally well to what takes place in the interior of the battery, as through the route of the conductors, and the body embraced between the poles. The galvanic *circuit* of a series, when closed, is indeed but a circle composed in parts and by bits of conductors, united end to end in the series of the battery through which the current circulates, in a manner perfectly uniform and identical. In this there is brought about a change, by a succession of polarizations and recompositions of the contrary electricities of the consecutive molecules, in such a way that if the current encounters *resistance* heat is evolved; if the molecules are compound, and the current is persistent, then there is chemical decomposition. All these effects are capable of being equal in all parts of the same circuit or circle, (for such it is,) including the contents of the cups themselves, on the one side, and no less so the matter included between the electrodes that is to be operated upon, on the other.

It is then understood that there is a marked difference between the quantity of electricity *produced*, and the quantity that actually *travels* the circuit, or, in other words, that penetrates and passes through the object of work that is between the poles. This is always more or less retarded, or facilitated, aside from the power or kind of battery, *according to the resistance* or poor conducting property *of the given object* that is acted upon. The result is necessarily different. There cannot be a current, as we have shown, without some degree of both quantity and intensity; but we now refer to these two relative properties. A single pair of almost any battery gives a quantity current, i. e., more of the character of *quantity* than of *intensity*. The former has the property for chemical decomposition, the latter for overcoming the resistance of an indifferent or bad conductor. Generally, we can increase the quantity by the larger extent of metal surface in the one battery cup; also by the kind of metals that constitute the pair, or by the increase of acids or salts in the liquid of the battery; in a word, by extensive and rapid oxidation or chemical action in the liquids or metals in a given time. But the *intensity* is increased, as we

have shown, by the increase of number in the pairs that compose the compound battery, but without an increase of size.

We conclude, then, that a galvanic current is great in *quantity*, and capable for chemical action, if produced by a single pair or more, much in proportion to the size and action of the pair if connected with a thick wire. The density, tension, and intensity of the current for passing over and through poor conductors will be much in proportion to the number of the series, and the smaller size of the wire connections and conductors. The efficiency of every battery depends upon good contacts. This is mentioned *particularly*, because the greatest and most frequent failures, partial failures, or differences of results, arise from this want of exact care.

There is another method for increasing the electro-motive force of even a small galvanic current of a single pair, as well as some modified *kind of intensity;* but this must be reserved for the next chapter.

*Derived currents*, spoken of by authors, are those that are obtained by a sort of *by-path*, namely, when the conductor of a closed circuit is conveying a galvanic current, this is termed the *primary current*. If, now, we add a short and nearly parallel conductor by making contact at its metallic ends, on the route of the primitive wire, a portion of the current will pass along the second wire, provided it is not much longer nor smaller, nor otherwise a poorer conductor, than the primary wire. And this is termed a *derived current*. The author, however, finds no use for such in therapeutics.

*Electric heat* is produced in the same way as electric light, by a rapid or extensive chemical action, in a single or compound galvanic battery; but instead of using both great quantity and intensity, we require only *quantity*, with very little intensity. Electric light cannot be, without some considerable heat; nor can we obtain electric heat without some considerable degree of light. This, however, is never a drawback, while it is often of the greatest advantage, as when required to use electric heat for cautery in deep cavities, as in the throat, rectum, or vagina. See *Electric Cautery*.

*Heat* can be produced by an obstructed or retarded current

of electricity, as, for instance, where a large quantity current is led by a wire too small to convey it all freely, or through a poor conductor, as *platinum*. It may be evolved by the disruptive discharge between the two poles of a galvanic battery, where disintegration is effected, and the particles of one pole pass over to the other pole, with the evolution of *intense heat* and light. If we but coil a fine bit of platinum wire into a small spiral, it may be heated, even *instantly*, to a white heat, by making contact with a galvanic battery of large-sized cups, of quick action, and few in number. Thus it can serve the most perfect office of a *cautery* that is known in surgery. For this purpose, as we have elsewhere explained, it takes some half dozen half-gallon jars of a Bunsen or Grove's battery. (See *Grenet's Battery.*)

It must be borne in mind that when using a compound galvanic battery of high series for remedial purposes, that the law of this current is *heat*, in proportion to the power of the current and the obstacle opposed. This capability of such a current is aroused, then, not only by a small or poor conducting wire, but also by passing through a portion of the human body, as in ordinary treatments. Therefore the operator must know that if the electrodes are retained for some time on the same spot, while a large current is flowing, there will be danger of producing a slough, simply from cooking the flesh by electric heat. Let the same current pass through a small quantity of water, as in a glass tube, and it is seen to be not only rapidly decomposed, but it also boils, and that instantly and furiously. But there need be no kind of danger of this accident occurring, except from sheer ignorance or carelessness.

### *Faradaic Batteries and Apparatus.*

*Induction* electricity,—i. e., currents obtained by the now well-known laws of induction styled galvano-magnetism, magneto-electricity, electro-magnetism, &c.,—when used for or spoken of in connection with medicine, the author has termed *faradaism*. This sort of apparatus we term *faradaic*, (pronounced *faradic*,) or *faradaic machines*. The peculiarly intense current of inter-

rupted electricity thus produced we term *the faradaic current.* The application of such currents is termed *faradaization.*

Professor Faraday was not the first discoverer of this manifestation of electricity, but he was the inventor of this class of electric apparatus. Therefore, in the first edition of this work, which appeared in 1860, the author, first of all, on page 141, blended the name of Faraday with both the cause and effect, so as clearly to distinguish this peculiar kind of machine and current from every other apparatus and manifestation of electricity. Thus *faradaic*, in contradistinction to *galvanic*, and *faradaism*, to be distinguished from *galvanism*, that we may no more confound them. We must carefully discriminate the primary current as differing widely *in action and result* from the secondary or induced current, in all electro-physiological and therapeutical operations and *reports.* Faradaic machines, faradaic currents, and faradaism are now becoming familiar terms, and being adopted by medical men in all parts of the world.

The term "*faradaization*" the author does not claim. Dr. Duchenne, of France, had long time ago already connected the name of Faraday *with a peculiar method of application* of these currents for remedial purposes. Hence "*faradaize*," "*faradaization*," and "*localized faradaization*" are of this origin, and are also being adopted as convenient and definite terms, in some late medical literature, — a just tribute to the great benefactor, — and will become points of accuracy for all future electro-medical statements.

### *Induction Currents.*

For a long time philosophers were impressed with the analogy there seemed to exist between electric and magnetic phenomena. There were manifested two magnetisms — the north and the south poles; as there were two electricities, plus and minus, or positive and negative. Indeed, very many of the phenomena of electricity in motion, are closely related to magnetism. The attractions and repulsions manifested between the two magnetisms, as between the two electricities, are according to similar laws.

In 1819 Professor Oersted, a Danish philosopher of Copen-

hagen, made the first scientific demonstration of the action of electricity upon a magnet. As Dr. Benjamin Franklin had demonstrated the identity of the lightning of the clouds with the spark of the friction machine, — which, indeed, had long been suspected and as much doubted, — so here was actually proved that which had been so long suspected and sought for by some, (while doubted and scouted by others,) but not where, and in the way, it had been thought to exist. The finding of M. Oersted was, that electricity acts upon a magnet, and that a magnet, in its turn, acts upon electricity; but *only* when the electricity is in motion.

The following is his fundamental experiment: When the poles of a galvanic battery are closed, so as to make a continuous conductor, and if this wire, while the current is traversing it, is placed either above or below a magnetic needle which is freely suspended and parallel to its direction, the needle is immediately deviated, and all the more considerable as the galvanic current is more powerful. It tends to place itself transverse and perpendicular to the conductor wire of the battery — a position it nearly attains, provided it is near, and the battery current is sufficiently strong. In fact, the extent of the deviation of the needle is directly proportional to the power of the battery, and inversely proportional to the distance between the needle and the wire. But if it is a common magnetic needle, it will not be deflected so far as to assume a position exactly at right angles with the conducting wire, on account of the influence of the earth, which still acts upon the needle, and tends to draw it back to its natural magnetic meridian. Therefore it will come to rest in a place between the two forces, according to the predominance of the one or the other. The direction in which the deviation takes place depends upon two circumstances: the first is, the *position* of the conducting wire of the battery in relation to the magnetic needle, as it may be above or under it, or it may pass it perpendicularly with an up-running or down-running current; the second condition is, the *direction* of the current.

Ampère drew the attention of natural philosophers to the fact that the earth's magnetism prevents the magnetized needle from

entirely obeying the influence of the electric current. To obviate this he proposed the *astatic needle*. He first, or M. Nobili, constructed this by placing a second needle above, parallel with, and near to, say within a half inch of, the traversing magnetic needle. The upper needle, being made fast on the same centre shaft with the first, moves on the same pivot; but its polarity is *reversed* as to the other, so as to neutralize its directive tendency in respect to the earth, and so that it shall remain at rest in any position. But the two needles cannot be *perfectly* alike in all respects, and possessed of absolutely the same quantity of magnetic power, and therefore the globe will always have some degree of effect upon the static needle. Yet it is certainly proved that the electric current does, more promptly and completely, control a needle so prepared as to be *double* and reversed than the *single* magnetized needle.

Fig. 48. Astatic Needle.

If the conducting wire of the galvanic current is placed horizontally below the needle so as to run north, the north pole of the needle is instantly deviated eastward. If the electric current is now reversed so as to run southward, the north pole of the needle flies to the west. But if now the conducting wire is raised above the needle, and still horizontal, the deviations of the needle always occur in the contrary direction.

While M. Ampère took up M. Oersted's discovery to generalize and extend it, M. Arago was looking into this matter, and soon showed that an electric current not only acts upon a magnetized needle, but that it also acts upon all magnetizable bodies, even when they are not magnetized. Having coiled a small, soft iron wire, he found that when this wire was being traversed by a strong electric current, it acquired the property of attracting and retaining around it a certain quantity of iron filings, much like a cylindrical envelope, but that the instant the current ceased to pass the filings fell off; but as soon as the current run again, the wire took them up again.

M. Arago further showed that the powerful charge of a Ley-

den jar even, may magnetize a steel needle, if placed in the interior of a helix made of metal wire through which this discharge is made to pass. Sir H. Davy soon afterwards discovered that we can magnetize common sewing needles by merely rubbing them back and forth transversely over a rectilinear wire *while* it is being traversed by the electric current of a battery. These experiments prove that the electric current impresses upon battery conductors, that are thus traversed, properties perfectly like those of magnets, not only those of magnetic bodies: but in fact it actually magnetizes those thus traversed.

M. Ampère found, besides, that a galvanic current not only acts upon a magnet, but that it also exercises an action upon another contiguous electric current, which may be stated thus:

If two portions of straight, movable wires have constant galvanic currents coursing through them, they are then mutually *attractive* and *attracted*, while the current is still moving in the same direction; but if one of them is reversed, so that they run in contrary directions, then they are *repelling* and *repelled*; and this is not instantaneous, as with static electricity, but is continuous as long as the current continues to traverse the conductors. Thus the ascertained action of an electric current upon a magnetized needle had furnished the means in every respect for determining the existence, and for appreciating the force, of any sort of electric current. Immediately M. Schweigger, a German philosopher, applied these principles to the construction of the first galvanometer multiplier, which was employed by M. Nobili in his wonderful electro-physiological researches. M. Dubois-Reymond then constructed on this same principle a galvanometer of the utmost sensitiveness, and as remarkable for its accuracy, by employing more than 24,000 elliptical convolutions of insulated fine wire, by which he was enabled to detect the presence of electric currents even in almost all the tissues of the living animal body; and by this superior aid he arrived at his fundamental and special laws in electro-physiology.

Very soon after Oersted's discovery, Arago demonstrated that if a copper wire that is well covered with silk thread and

varnish be rolled into the form of a helix around a bar of soft iron, and an electric current is then caused to pass through the wire so coiled and situated, *the soft iron becomes a powerful magnet*, and remains so as long as the current runs. He showed that it is with the greatest rapidity that soft iron is magnetized and demagnetized by the electric current. Such temporary magnets are termed *electro*-magnets, in order to distinguish them from permanent magnets of steel. Thus on, he showed that the electric current imparted a magnetic property to pieces of soft iron *temporarily*, to steel *permanently*, also to other bodies that did not possess it previously.

The term "*electricity of induction*" strictly means the development of electricity by the influence of other electricity in proximity, or else by means of magnetism. That developed by the influence of the former is called electro-static or electro-dynamic induction, and also *electro-magnetism;* that of the latter is termed magneto-electric induction or *magneto-electricity*. When two *helices* (which are, indeed, but coils or bobbins of wire in which galvanic currents are then flowing in the same direction) are placed end to end, they attract each other; but if one of them is reversed, so as to give opposite currents, repulsion is manifested. So, according to Ampère's theory, when two permanent steel magnets are placed end to end, there is attraction or repulsion on the same principle.

If we take a Smee's battery, or a good sized and active sulphate of copper battery, and connect the poles by a *short* copper wire, no spark is usually perceived when the connection is formed or broken, but, if any, never at contact, and only very faint when opened. But if this connection wire is replaced by one that is fifty or a hundred feet long, the spark appears much brighter and more certain; but if we *coil* this wire as on a spool, then the spark is still more vivid and more uniform. The most advantageous length of wire coil for producing the greatest spark depends upon the diameter and quality of the wire, and also upon the quantity and intensity of the battery. If a battery of higher intensity is employed, such as Grove's, then the wire may be much further increased; but the greater the

*quantity* of the electric current, the *shorter* or *larger* must be this wire in order to transmit the whole of the current, and to obtain the greatest effect or the brightest spark. By means of a wire some hundreds of feet in length, a slight shock may be felt from a single pair at the moment of opening the circuit, if its poles are arranged as moist electrodes, and are held in the hands. By testing it through the tongue, this intensity increases until the wire is some six or seven hundred feet long: by using a number of pairs, or even a smaller size, a greater length of wire in helix can be employed for shock or spark with greater effect. The maximum effects of a single small battery are, of course, less than those of a large one, and if the requisite length of wire for the given battery current is exceeded, the effects are diminished.

In 1831, Professor Henry, one of our American philosophers, was the first to discover this peculiar action of a long conductor when extended, and also, when *coiled into a helix*, as so modifying or *increasing* the current of a single galvanic pair *at the moment when it ceases to flow*. He was the first to employ coils of *metallic ribbon* for obtaining sparks and shocks from a single galvanic pair. By this means the brilliancy and power of the spark are very greatly increased whenever the circuit is broken.

Thus far had this branch of science advanced when in the same year Professor Faraday, of England, discovered that an *electric current*, as well as a *magnet*, *is able by induction to develop electric currents* in conducting wires. This he proved by placing on an insulating plane two parallel conducting wires very near to each other, but without touching. The two ends of one of these wires are connected with the poles of a galvanic battery, so that it in fact becomes the connecting wire between the two poles of that battery. The two ends of the other wire are connected with the extremities of a sensitive galvanometer, simply to judge of the electric movement in this wire, if any, by the deviations of the needle of the instrument. At the moment the battery current commences to flow through the first wire, the needle of the instrument is seen to deviate at first, then to quiver and oscillate, and finally to come back to an equilibrium,

which remains at zero, just as it was before the current was let on the first wire; and thus it remains undisturbed as long as the current of the battery continues to traverse the neighboring wire; but the instant the current is interrupted in the first wire, the needle suffers another deflection, and this in a contrary direction to that which occurred at the closure of the current. Thus he proved that the galvanic current which courses through the one wire, determines an instantaneous but opposite current in the other wire *at the moment when it begins to flow, and another equally instantaneous reverse current at the moment when it ceases.*

Dr. Faraday was led to suppose, from the manifest analogy existing between the properties of *magnets* and those of electro-dynamic *coils* or helices, that the same results would be obtained by introducing into the interior of the hollow helix a magnet instead of the electro-dynamic coil; and this he demonstrated to be so, and that even in a much stronger degree. In fact, the electric current that traverses one of the helices or coils of the machine at the moment when it is established, not only de-

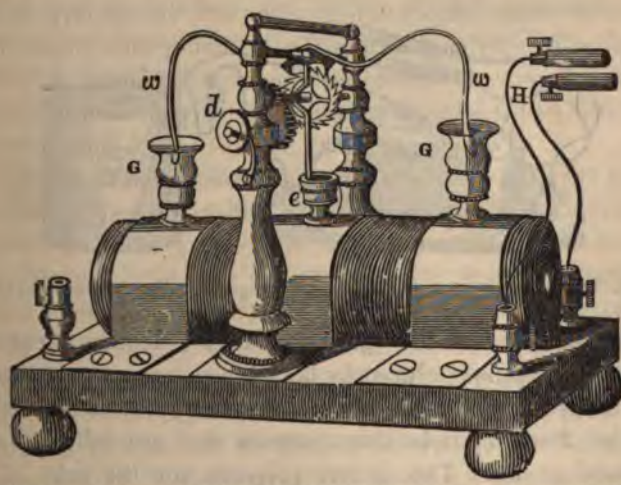



Fig. 49. An Electro-Magnetic Double Helix, with Clock-work for interrupting the Primary or Battery Current.

termines a current of electro-dynamic induction in the other coil of the helix, but at the same time, if there is placed a soft

iron within the helix, it magnetizes it; and for this same reason also determines in the second coil a magneto-electric current *in the same direction, and much more powerful.* So, when the current *ceases* to pass, the soft iron being instantly demagnetized, there is developed a second induced current *from the magnet*, which is now also added to that which results from the direct effect on the second wire in the helix — all proceeding from the inducing current that is flowing from the battery through the first wire in the helix.

The first physician who employed *induction currents* for medical purposes was Dr. Neef, of Frankfort-on-the-Main. He first *invented* the automatic vibrating spring for interrupting the current, which indeed opened a new *era* in the therapeutical uses of electricity.

*Electro-magnetic currents*, as they have been more generally called, are usually obtained from a helix machine, in connection with a single galvanic pair, (which latter is of itself a battery;) but, taken together, this is known in our country as the *Electro-magnetic Machine.* The *kind* of electricity thus obtained could

Fig. 50. Electro-magnetic Helix and Battery, with a Rasp for breaking the Current by hand.

be more strictly termed "galvano-magneto-electric currents of induction," because induced by both these sources combined, by the arrangement of one and the same apparatus. There are also other forms of induction currents that are called by other compound names. The author proposes, for the sake of conciseness and uniformity, to designate the peculiar kind of electricity obtained by any and all sorts of *induction* apparatus, whether from battery or permanent steel magnets, in connection

with *medical purposes*, as *Faradaic electricity*, *Faradaic currents*, and so on. True, the initiatory steps that led on to this grand discovery had already been taken by Oersted, Ampère, Arago, and by Henry; yet to the illustrious English philosopher, Dr. Faraday, are we indebted most of all for this magnificent result. Besides, it is well known that Dr. Duchenne, of France, one of the most distinguished medical electricians of the age, has already designated, in his elaborate work, the "localization of induction currents to a single muscle" as "*Faradization*." Let that kind of *current*, then, in this relation, and the medical use of these currents, henceforth take his name.

The term *Faradaic electricity*, wherever it may recur in this work, is simply synonymous with the terms "induction currents," "electro-magnetism," or "magneto-electricity," and stands in contradistinction to *Galvanic electricity*, for this latter term I confine strictly to primary battery currents.

The Electro-magnetic Machine gives us one of the most important forms of induction currents with which we have to do in all electro-therapeutics. Under this head, then, we must consider the construction and action of such apparatus, which are important, inasmuch as they have been, and still are, the more frequently resorted to for medical purposes. And withal, it seems but reasonable that a medical man should well understand the instrument with which he proposes to operate.

To be the better understood, we will set out with the primary law of physics, namely, that we can only derive force from some prior change of matter, which change ultimately resolves itself into some new form. If we find we have a certain amount of action in a *single* galvanic battery, it is given us as the effect of relative quantity. When the action takes place in a *series* of elements, i. e., in more than one pair, then, in proportion to the number used, do we get the relative effects of intensity. Moreover all the kinds of electro-magnetic machines yield us a current of peculiar *intensity*, although from a single galvanic pair whose simple characteristic is *quantity*. This excellent result is obtained by the power electricity possesses when passing through

Fig. 51. Electro-magnetic Helix, with Vibrating Electrotome, but without its Battery.

a parallel and approximating wire, particularly when these wires are wound into coils of given lengths; and still more is the greatness of this result enhanced by the magnetic power that is also developed and exercised simultaneously in the same direction.

The coil or helix of all these machines, that are useful, is made pretty much *on the same principle*. A stout copper wire is well covered with cotton thread and varnish, for perfect insulation; and then some ten to fifteen yards of this is first wound into a coil, (which forms the inside of the helix of every such machine,) so as to allow the two ends of this coarse wire coil, which is but a part of the helix, to connect with the galvanic battery. This is termed the *inducing wire*, and the current of the battery when passing through this inner and stouter wire is designated the *inducing current*. Indeed, this current does *induce* the additional power from *two sources* — the one from a bundle of soft iron wires or a piece of soft iron that is placed within the central cylindrical cavity in the helix, and the other power from the outer and second coil of the helix, that will soon be described. But to understand as we go. If, now, into the interior of this primary coil of wire there is inserted the piece of soft iron or the bundle of wires while the current flows through the coil, the wire or iron is magnetized by the power of the current that is only passing from the battery through the helix and back to the battery. This is proved by the visible effects on a common magnetic needle placed under the wire, but very close to it; or it is seen the better by a galvanometer, so arranged that the current passes through this instrument, when it is found to be very decidedly increased, because there is added to the primary current of the battery *the induced current from magnetic induction.*

To finish the helix as it is, or *should be*, there is wound on or over the bobbin of coarse *copper* wire, that we have just been experimenting with, a second coil of fine copper wire of good quality, that is also well covered with silk or cotton thread and varnish, for perfect insulation: of this there should be at least five hundred to fifteen hundred feet, closely laid in the same direction over the coarse inducing wire. When thus completed, the two ends of the primary or coarse inducing wire lead to, and connect with, the battery. The two ends of the outer secondary fine induction wire lead to binding screws, with which the electrodes and conductors can be adjusted so as to lead to the patient. A third coil yields a different intensity.

It has already been shown that when contact is made with the battery, the current which passes through the inner primary coarse wire determines in the second or outer longer and finer wire an instantaneous current *at the moment* when it *begins* to circulate, and another equally instantaneous current *at the moment* when it *ceases* to pass. Now, here is the peculiarity of this current from *electric induction;* i. e., it is thus always instantaneous, and that at the instant the inducing current *starts*, and again when it *stops*. The same is true of the currents of *magnetic induction*. And, fortunately, the magnetic current *can* act not only instantaneously and simultaneously, but also in the same direction with the other bits of currents; for these latter are not produced whilst the soft iron remains a magnet, but rather only when it gains and loses its magnetism. The demagnetization of the soft iron within the helix machine, therefore, must have the same effect as breaking the current of the battery in the production of an equally instantaneous current. It is clearly understood, then, that the current of the battery which circulates in the coarse wire of the helix never arrives at the patient. It is only the *induced* currents (from the two sources, namely, from the within magnetized soft iron, and the without long fine coil of the helix that is rendered electric *simultaneously* by the mutual action of the battery and the magnet) that are felt at the electrodes. The galvanometer indicates exactly, not only

the existence of such currents as being only and always instantaneous, but also their *direction;* for if we compare the direction of the different currents, we find that the induced current — i. e., the one in the fine long wire that leads to the electrodes on *making* the circuit — is *contrary* to that of the current of the battery; while the direction of the one on *breaking* the circuit is in the *same* direction with that of the battery. We therefore find the *law, that these kinds of currents are but shocks, of only instantaneous duration, and that the direction of each alternate shock or current is invariably and necessarily in the contrary direction.*

To render such an arrangement available as a kind of *current*, there must be some contrivance for breaking and making the original or inducing current of the battery with the greatest possible rapidity and uniformity; and this is most beautifully accomplished in the best of these machines by the "*trembler*" of Dr. Neef. This is done by electro-magnetic power acting automatically on a magnet of soft iron, about which are made several coils of the large wire that forms the inner coil of the helix and connects with the battery. There is placed over the arms of this miniature magnet a silver spring that is faced and loaded like a hammer with a small bit of soft iron. This spring vibrates, with a mere hum from rapidity between the tips of the magnet and the end of an adjustable screw at its back, which is also tipped, but with a point of platinum; and this strikes against a pin-head button of platinum attached to the silver spring. And here is the most delicate point in the whole apparatus. These platinum points *should be riveted* to their place, *but never soldered.* The solder will become decomposed by the electric spark that plays there, and after a while the machine appears to be uncertain, or even worthless, although perhaps a good machine in every other respect. The author must say he has seen not a few of such; and not only so, but he has often found the apparently good-sized helix stuffed with something, besides a thousand feet of insulated *copper* wire!

Fig. 52.
Electro-Magnet.

But to return. We have said that the original current of the battery is interrupted by the magnetic force of attraction and repulsion acting upon the silver spring, which is interposed so as to separate, and join the contact or continuity of the battery wire. The battery current renders the little soft iron a magnet, and this attracts the spring-hammer, and that demagnetizes the little magnet which allows the spring to fly back again; and thus is the current made and broken more rapidly and uniformly by electro-magnetic action than can be possibly done by any other mechanical arrangement. I should also mention, that the *face* of the iron on the spring should be kept clean and bright, as well

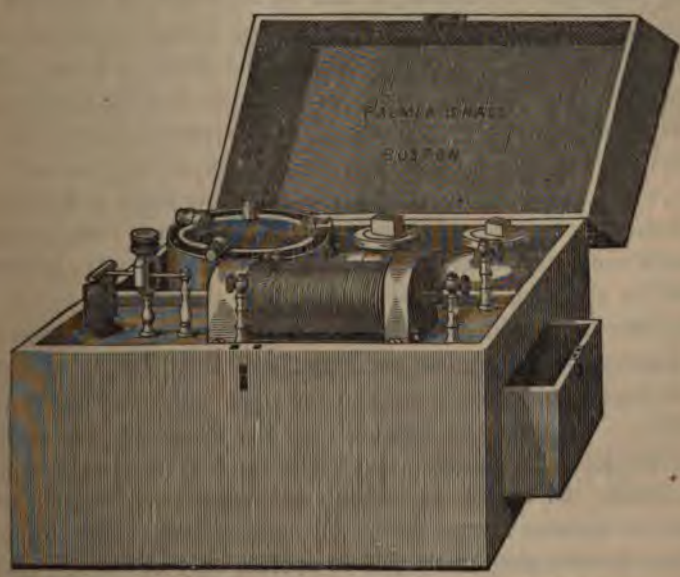


Fig. 53. Electro-Magnetic Portable Machine, complete in its Box.

as the ends of the arms of the little magnet, for either grease or rust will stop its action. The *contacts* must all be carefully attended to. Much power is often lost by this neglect, besides the inconvenience of uncertain action, or no action at all.

Go where we will, as I have said, we find a great variety of these electro-magnetic machines. Nevertheless, they possess in the main, generally, the same principle, and about the same internal arrangement or property for obtaining, in a greater or less degree, an *intermitting and alternating current of intensity*, simply from a single galvanic battery of great relative quantity. Some of these are good, others are not.

The intensity of these induction currents from a given machine depends, in the first place, upon the intensity of the battery action. If this is any way feeble, it will not develop a powerful magnetism; therefore the extra current from this source, as well as the current induced in the second or outer wire will be of low tension. The current can be made more heating and chemical by using a large and active battery with strong solution. Of course, it can be regulated or reversed in this respect, even to the lowest degree, by lifting the metal pair partly out of the fluid, or by diluting the fluid, or both. The intensity of the current, as regards tension, can be graduated to the greatest nicety by adjusting the soft iron or the bundle of wires that can be more or less pulled out of the end of the helix, which reduces the current, while pushing them in increases the current. So great is this range of difference that it is absolutely necessary to graduate the current in this way, invariably *before* applying the moist electrodes to the patient.

Another important point is to have the machine attached to the battery *invariably but one way;* and it is better to have the strongest pole always come to the right hand as we face the machine. We then can keep in view the whole, for this is the negative electrode, and the point where the current always leaves the patient. Of course, the other must be the positive pole, and where the current always enters the body or limb of the patient. By thus accustoming one's self to operate only in one way, it is more easy to keep the whole story of "current direction" clear, while the mind is more intent on the anatomical and physiological phenomena of the case. It is easy to determine which is the strongest, and hence negative electrode, by simply pressing the moist wash-leather or sponge of each electrode into the palm

of each hand, and particularly if so as to cover the inner edge of the adductors of the thumbs, which will respond by contraction most strongly to the negative electrode. The current should be strong, and the moist electrodes should be exchanged from hand to hand, back and forth, several times, until this is fairly demonstrated to our satisfaction.

*A combined compound galvanic and faradaic battery* (primary and secondary) *made portable*, expressly for medical uses, by Messieurs Legendre and Morin, of Paris, is a neat and most efficient arrangement. It is composed of thirty cups compactly set in a box for a compound primary current, as also a faradaic current battery. By the term *compound* we mean that whereas one cup is called a battery, so two or more, when attached together by wire from the carbon of one cup to the zinc of the next cup, are also called a battery; but it is compound, being made up of many cups or cells. This admirable battery is portable, and yet consists of thirty elements or cups, which are some five inches in circumference and four in depth, composed of *Delleuel's carbon*, which forms one pole, while the contained pole of zinc is amalgamated with quicksilver, and the charge is composed of forty-nine parts of water to one of nitric acid.

One of these cups is sufficient to put in action a most powerful induction coil for producing also a faradaic current. Two or more cups may thus be used. From three to thirty of these cups, when employed without the helix, yield a true primary current of so much quantity and intensity, for chemical action, that it rapidly reddens the skin, quickens the nerves and circulation, and warms the part, or the whole person.

The acid fumes from this battery cannot escape, as each cup is closely covered by hard gutta percha, and the whole is fitted into a secure and portable nest. The metallic connections, from cup to cup, are perforated so as to readily receive the wire tips of the conductors for the electrodes, which may thus be made to embrace any number of elements, without the need of a key-board, and measure the amount of current tolerably well without a galvanometer.

*Chester's Pocket Battery.* — This is in *a very small* box, yet is capable of yielding great power, either as an *extra* or as a true faradaic current. It is on the principle of the Rhumkorff carbon-cup battery, so generally used by the profession in Paris. Two tea-spoonfuls of water, to wet the powdered deuto-sulphate of mercury in the little carbon cups, is all the liquid required. It is all encased in a pocket box about six inches long, four wide, and two deep, and is calculated for medical purposes.

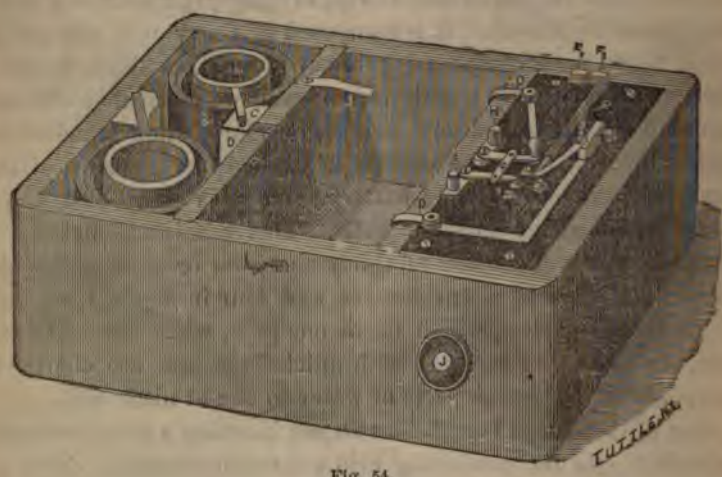


Fig. 54.

No acids are required. The two carbon cups are removable by pressing up with the finger through holes in the box bottom. Connection is formed with the outside of the carbon cups by *platina*-faced springs, while the zincs make connection by dropping into their places within the carbon cups, but without touching them. Thus *c d* represent the zinc and the carbon battery poles, while *j* shows a switch that throws the battery on or off instantly; and *h i* are the attachments for flexible insulated conductors, with their electrodes. The switch *a*, when swung to the left, gives the one-way increased current (*extra*) to the electrodes — to the right, gives the secondary, or faradaic current. This neat little instrument is made by Charles T. & I. N. Chester, electrical instrument makers, 104 Centre Street, New York.

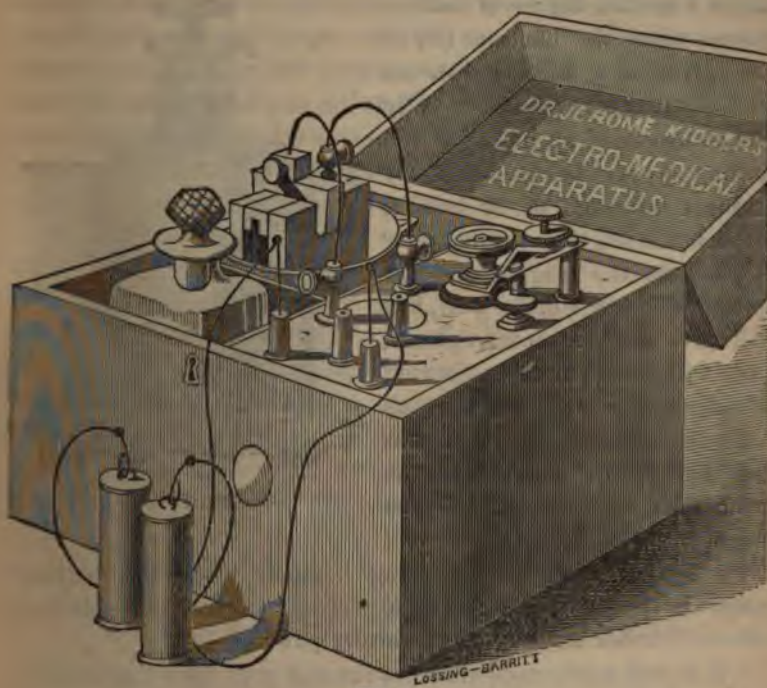



Fig. 55.

*The Kidder Battery.* — This is a modified electro-magnetic apparatus, manufactured by Jerome Kidder, of 483 Broadway, New York. It is a patented machine, and he has kindly sent me one of his new pattern, together with the specification of his letters patent. The *inducing* battery power of the Kidder machine is a Smee battery arrangement, as can be seen in the cut, such as is now frequently found in modern portable chemical apparatus. But his *tripod helix* has peculiarities that appear to me new and valuable; so we may say of his electro-magnet vibrator. Instead of depending only on the set-screw on the middle of the vibrator, he provides a movable clamp, and approximates or recedes the magnet also by means of an adjustable screw head in the end of the magnet, as may be seen in Fig. 55.

"The spring will vibrate well under a certain degree of battery power, when the hammer (b) of the spring is a definite distance from the magnet, which is usually one sixteenth of an inch. If the battery power be increased by stronger solution, or by adding more batteries, then the hammer is too near the magnet, and the spring will not vibrate well, but will give unequal interruptions, and will also make a jarring sound, unpleasant to nervous patients. He has obviated this difficulty by the screw with its head (A) in the end of the magnet, which can be *turned down* farther from the vibrating hammer when the battery power is strong, thus securing a perfectly smooth and noiseless vibration under all degrees of battery power.

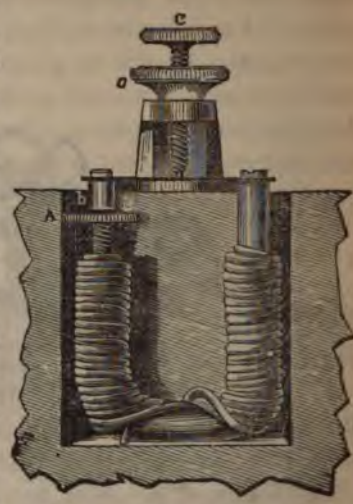


Fig. 56.

"It is well understood that the current goes from the positive to the negative, and that two, and two only, of these posts are to be used for a current, as it is necessary to have a positive and negative in order to secure the same. When we have desired to represent simply electro-magnetic induction, without the galvanic current which electro-plates, we have used two arrows, one smaller than the other, and pointing in opposite directions; and we have called the current *alternating*, because it has been so called by various writers on electricity. But let it be distinctly understood that the use of this term does not express the exact quality of the current in this respect, especially as it works when the human body is a part of the closed circuit. It should, perhaps, be represented without the use of the smaller arrow, because the weaker current is so slight that it should not be considered, as under ordinary circumstances it cannot be perceived.

"The various currents of this *apparatus* are given out from

some two of the four posts lettered A, B, C, D. Each of these currents has different qualities. The right-hand post (A) to the centre post (D) will cause contractions of the muscles without much sensation: it is the combined power of the battery. From A to the rear post (B) is of low *tension*, and yields a strong *one-way* increased current (*extra*).

"Tension is not *power*, but a *quality* of current. If the current C and D (low tension) be made strong by *strong battery* power, it will act on the sentient nerves with cutting pain *near* where the electrodes are applied. Currents of high tension have greater conductibility, and will therefore traverse mediums where a current of low tension will not."

It is shown that each of the three coils of this helix is of different size wire, and different length, and so arranged as to be employed separately or together.

The following diagram, however, it seems to us, more clearly illustrates the sources of these modified currents:—

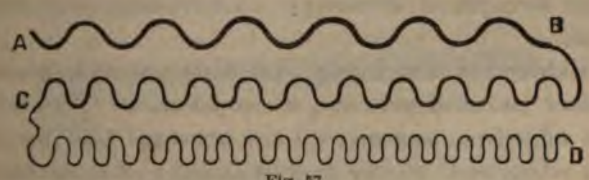



Fig. 57.

A to B represents the inducing large inner short coil, through which the primary current passes from the platinum plate in the Smee battery around to the amalgamated, quicksilvered zinc plate in the same, and thus *induces* currents in the outer coils. B to C is a much finer and longer wire, and represents the ordinary second coil of all helices; except that it is finer and longer, and of better material and better insulated, than is found in ordinary older faradaic machines. C to D represents the third or outer coil, which is of still finer wire, and yields a different power, if the conductors are at B and D; and when the battery power is adequate, it is of most powerful influence, *by intensity*, for conduction and penetration.

Hence, when the conductors that lead to the electrodes are inserted, on the top of the machine, as seen in Fig. 55, at A

and B, we get a small one-way current of galvanism together with a moderate current of faradaism combined, which is very highly esteemed by Dr. Duchenne, and termed by him the "*extra current*" of induction. It is often spoken of as a "direct" current. A and C affords the same, vastly modified by greater power of induction, and hence more intense; but adjustable by means of the withdrawing or insertion of the inner bundle of soft iron rods through the side of the containing box or case. B and C gives the usual induced current. A and D affords the whole combined power of this apparatus, provided the battery strength is proportionably increased. Thus we get a still greater power of tension and conduction, capable of overcoming greater resistance, and of influencing a nerve-trunk or nerve-centre situated farther from the site of the electrodes, and for producing, *without* more sensation or pain, more reflex action.

*B and C yields the ordinary faradaic current*, and is probably the one that is most frequently required; while B and D affords an extra strength of intensity — an advantage very frequently required.

Mr. Kidder has also kindly sent drawings and specifications of another patented machine, where he claims "two helices, or systems of helices, so combined and arranged that the induced current or currents of one may be added to the current or currents of the other; also, that the current or currents of one may be made to run in opposite direction to the current or currents of another, for the purpose of cutting off the power." This apparatus we have not seen, nor can we fully comprehend the utility of all the parts. But this, perhaps, may be inferred from his own explanation of the action of the helix of faradaic machines generally: —

"To produce a strong sensational current by means of a single galvanic battery, it is necessary that magnetism should be alternately produced and destroyed, in proximity with a coil or helix of insulated wire. If within the chamber of a cylindrical coil of insulated wire a permanent magnet of steel be suddenly introduced, a person holding the terminals of that wire will feel a shock caused by electricity then induced in the coil. If the permanent magnet of steel be suddenly withdrawn, another

shock is felt, as another current is also then induced in the coil. These two sensational currents, in *this case*, are in opposite directions, and are equal. Not so with the inductive influence excited by means of an electro-magnet, produced by a galvanic battery.

"Instead of introducing and withdrawing a permanent magnet of steel, if a soft iron core, or a bundle of wires within the chamber of the helix, be suddenly magnetized and demagnetized by means of the closing and interrupting of the primary current of the galvanic battery passing round it on an insulated coil of wire, the same result is also obtained as in the first-mentioned case, *with this exception:* the party holding the ends of the coil of fine wire will experience comparatively no sensational effect when the circuit of the battery is *closed*, but a strong sensation when it is broken. Though this fact is well known to those informed in regard to electrical phenomena, yet the cause of this discrepancy, we think, has not before been given; we will therefore call attention to it, as it appears susceptible of easy and positive demonstration.

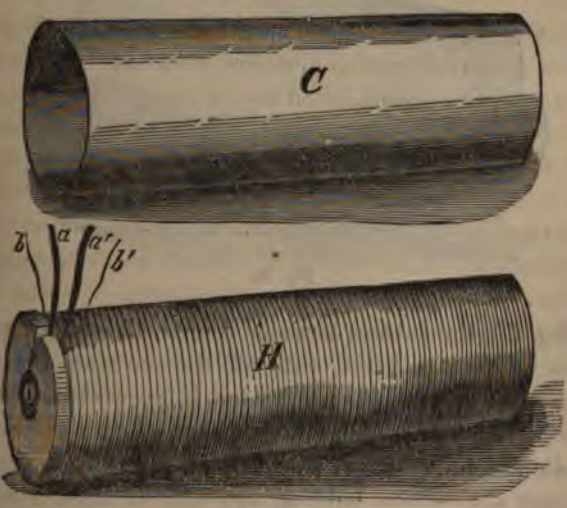



Fig. 58.

"In Fig. 58, *H* represents a cylinder consisting of two helices of insulated wire, the inner one having its terminals at *a*, *a'*,

and the outer at *b*, *b'*; *O* represents the opening of the chamber of the cylinder, which receives a core of soft iron that produces in the outer coil, *b*, *b'*, a *sensational* current when the primary current from the battery passing through *a*, *a'*, is broken, but *not* when the circuit of the primary current is closed, the reason of which will be perceived. If the copper or brass tube *C* be placed over the helix *H*, the sensational current is found to be wanting also in the coil *b*, *b'*, when the primary current is broken, because this tubular cylinder, *C*, receives within itself the inductive influence; it receives it because it is *closed* about the helix, and is a much more perfect conductor than the human hands: it thus cuts off the sensational current from the helix.

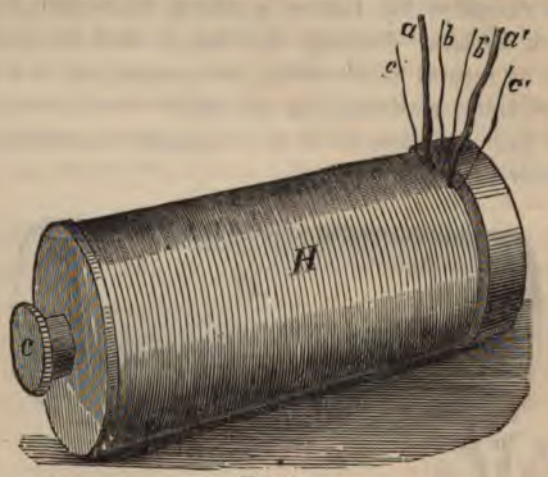



Fig. 59.

"In Fig. 59, the tube of brass or copper, *C*, enclosing the soft iron core *within* the helix, cuts off the currents the same as though it were over the helix. Also, if we withdraw the tube, *C*, and *close the ends*, *c*, *c'*, of the outer coil, the same effect is produced: the induced current is received within that closed coil, so that the person holding the ends of another coil, *b*, *b'*, would not receive the current; and *vice versa*, if the ends of the coil *b*, *b'*, be brought together, then the current would be received in that coil, and the person holding the ends of the outer coil,

$c$, $c'$, would not receive the current. Now, the operation of the machine *necessitates* the *closing and opening* of the coil $a$, $a'$, for the primary current to magnetize and demagnetize the central core of wire. And when the coil $a$, $a'$ is closed to produce the magnetism which would otherwise induce a current in the outer coils, *the very closing of that coil* with the battery causes it to *receive within itself the inductive influence that would otherwise be transmitted to the other coil or coils.* Therefore, *as regards the* SENSATIONAL EFFECTS, it is IMPOSSIBLE, as well as *not desirable*, to make it *to and fro.* It cannot alternate in an equal manner. *All electro-magnetic machines (those that are excited by the battery) come under this rule.*

"The fact that the primary current is weaker at the first moment of closing the circuit — it not being instantly produced in its maximum strength — has been presented as a cause for the comparative absence of the sensational current on closing the primary circuit; but this is not, of itself, a sufficient explanation. The true cause is the closed coil itself acting in the manner as above explained.

"The interruptions of the primary circuit by means of the spring can be definitely controlled, so that the experimenter *may know when* the circuit is closed, *and when* it is opened, by taking hold of the spring, pressing it against the platinum point, and then removing it. And to experience the result at the same time, hold in the hands the handles or electrodes attached to the conducting cords receiving the current: the comparative strength of the sensational currents in opposite directions *may thus be known by experience;* and it will be found in accordance with the foregoing statements, viz., when the circuit is closed, comparatively a very slight, or almost no sensation at all, is felt; but on opening the circuit, a strong sensation is experienced.

"In closing the ends of the coil receiving an induced current caused by an electro-magnet, that magnet is stronger at the moment of the production of the induced current, and gives up its magnetism, resuming its unmagnetized state quicker on breaking the primary circuit when there is a secondary current produced by a closed secondary coil. Therefore, in running a machine, the vibrations of the spring will be stronger, or more

forcible when the ends of the inductive coil are closed. If this inductive coil, receiving the induced current, be constituted of long and fine wire, developing its corresponding quality of current, the greater change in the magnet will be observed or indicated by the still stronger vibration of the spring. To show this effect, nice adjustment of the hammer of the spring, so as in its vibrations to barely escape touching the end of the U-shaped magnet, is necessary; then close the ends of the coil of induction, and the hammer oscillates so as to strike against the magnet. This phenomenon may truly indicate the compound nature of electricity, and unfold more clearly the laws governing magnetic induction."

Thus we see that the sensational (induced) currents of electricity differ in regard to their concentrated and diffused action on muscular and nerve tissue, and also in regard to their action on the sentient and motor nerves. This difference in physiological effect results in a great degree from the difference in the conductibility or intensity of different currents.

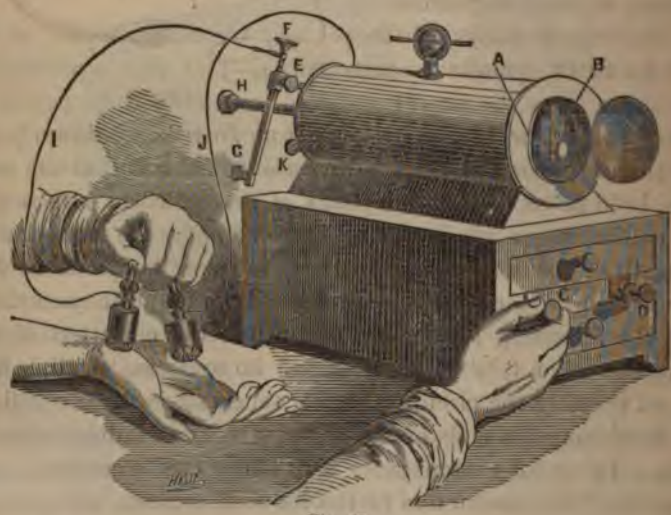



Fig. 60.

Fig. 60 illustrates the famous apparatus of Dr. Duchenne, of Boulogne, which yields two sorts of induced currents — the common faradaic current, and the *extra* current, which so much

resembles, in physiological effect, the true primary current; (it also gives a primary, sufficient for electro-puncture.) The galvanic, or *inducing*, part of this machine is very powerful; being, probably, more than five times as strong as the ordinary galvano-electric apparatus generally used in our country. The helix appears to be like those of other manufacture. Dr. Duchenne speaks of "producing sparks from the 'exciters,' along the surface of the dry skin," during his peculiar process of "*localized faradaization.*" The ordinary galvano-magnetic apparatus, such as we generally see, cannot produce this effect. This same figure illustrates his "*method of holding the exciters*" for performing localized faradaization on any part of the body or limbs.

Fig. 61 shows his "*exciters*," which are synonymous with what I term *electrodes*, and simply mean the terminals of the conductors, for applying electricity to the human body, whether they be moist sponges or metals.

Fig. 61.

The two *connection wires that lead from the battery to the helix*, in every galvano-magneto-electric apparatus of any sort, should be large, or else composed of several strands of copper wire, sufficient to conduct, readily, *all the quantity* current that flows with so *little intensity* from a single or only double cell, as provided in these portable boxes. But, on the contrary, the *conductors* that lead from the apparatus to the electrodes, and so to the patient, should *not* be of large wire, because it is not sufficiently flexible to admit of certain delicate adjustments of the electrodes, so desirable, if not absolutely indispensable. These long conductors convey an *intense* current, and hence may be small. They are best when made of fine copper wire, twisted into *a metallic twine*, and covered with silk, or India-rubber tubing.

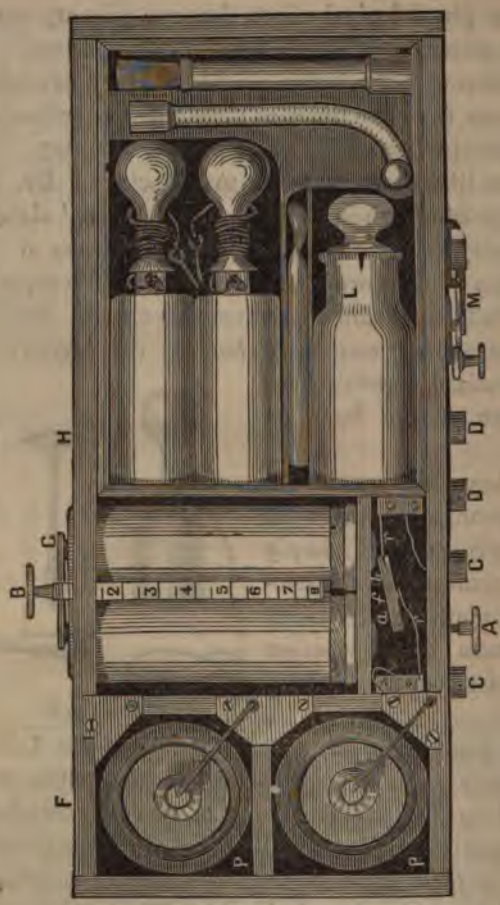



Fig. 62.

Fig. 62 represents that most portable and powerful little medico-electrical apparatus made by Ruhmkorff, in Paris. It is not so large as this book, and is not very liable to break or get out of order. The sockets C C yield the *extra*, or one-way current that so much resembles the primary. This current is very strong, but it can be regulated. D D affords the common faradaic current — and a most powerful current it is. G is a double helix of very fine copper wire, which is covered with a silvered shield that regulates the strength of the current. At P P there are

two carbon cups, in which we place about twenty or thirty grains of the bisulphate of mercury, from the bottle L. This is moistened with only one tea-spoonful of water, in each cup, and then the zincs, hanging by their side stems, fitted into metallic holes, are adjusted — when the whole is in operation to some purpose. The ratchet wheel at M is for suddenly interrupting the current. Thus it will run for an hour. Then the cups must be cleansed, and when put away, the accumulated quicksilver on the zincs must be shaken off, and the whole made dry for shutting up. The moist sponge electrodes, conductors, and other appliances should be placed in another box by themselves.

Fig. 63 represents Thomas Hall's celebrated portable medical apparatus. It is a faradaic arrangement, run by a Smee battery, most neatly and compactly encased in a small hard-wood box. It is clean, durable, and economical. It will run a week or two, or even a month, according to the amount of work it has to perform, without repairing or cleaning. But it is always best, and most economical, in using any Smee battery, to re-amalgamate the plates with quicksilver, and make a new solution (composed simply of twelve ounces of water and two of sulphuric acid)

Fig. 63.

every week or two. This apparatus is also provided with *switches* and *covers*, which render it convenient and tidy; and as it affords two kinds of electric currents, — the common faradaic, as also the *extra* current, and sufficient primary for electro-puncture, — it is reckoned as one of our best American electro-medical batteries, especially for office use.

*Directions for using it.* — Raise the zincs out of the box, and fill the glass vessel to within one inch and a half of the top with water; add one ounce (or two table-spoonfuls) of common sulphuric acid, which should be bright and clear; then place the zincs in this solution, adjust the cover, connect the brass strap with the brass post opposite by crowding the pin into the hole, being sure that it makes good contact.

Move the lever, or switch, marked B, into the post opposite; this brings the battery in connection with the instrument, or helix, which will instantly vibrate the armature. It is necessary to give the armature an impulse with the finger if it does not start quickly of its own accord.

To stop the action, disconnect the battery by removing the switch from the post, as the zincs are only in action while the lever is on the post.

The battery part consists of plates of amalgamated zincs, and of platinum. The zincs must be covered with quicksilver, by being first immersed in a solution of about one tenth sulphuric acid and nine of water. This solution thoroughly cleans the zincs, so that the mercury can amalgamate with them. It is best to rub the mercury on well with a piece of cloth or a stiff tooth-brush. Care should be taken to avoid touching the platinum plate with the mercury; also, to keep the zinc plates well coated with quicksilver.

The platinum, or centre plate, must not touch the zincs, as this would stop the action of the battery. The electrodes are connected with the flexible rubber-covered conductors by screws, and the other ends of the conductors are to be passed through the eyelets of the box, and connected with the screws marked P and N, representing the positive and negative poles of the apparatus. By this arrangement the box can be shut, while operating, and so avoid the noise of the vibrator.

After running some time, if the current becomes too feeble, look at the zinc plates. If they appear blackish, they need re-amalgamating with mercury; but if they are bright, and coated with the mercury, the solution must be at fault. Never add acid to an old solution, but throw it away, and prepare new.

After having seen that the zincs are in good order, and that the solution of acid and water is clear and strong, if the instrument still refuses to operate, the fault must be in the vibrator. The armature must be adjusted so that the iron hammer, which must not be *rusty*, is about a sixteenth of an inch from the face of the magnet; then screw the spiral spring down so as to just touch the flat spring; then tighten the screw firmly by the lower nut until the battery works.

The strength of the current is regulated mostly by the brass tube being moved out or in through the eyelet-hole of the box. When this tube or rod is entirely out, there is no perceptible current; but as it is gradually inserted, it increases the current until it is entirely in, when the instrument will be at great strength. More acid in the solution will add still more strength to the current; and a certain fine and exact adjustment of the vibrator will greatly enhance the strength and evenness of the induced current.

The extra current, or the common faradaic current, as we may need, may either of them be readily brought to the electrodes by a switch on the deck of the instrument. When this switch is on the knob of brass marked S, we get the true faradaic current; when it is on the knob marked P, we get the less painful, but more chemical, "*extra current.*" The different currents are thus obtained, or changed, by merely moving the switch from one knob to another. This machine is very durable.

*Hall's Petit Battery.* — This is the most compact, portable, and powerful little battery of any description that is produced in this country. It is made by T. Hall, 15 Bromfield Street, Boston, and is for sale by all surgical instrument dealers in the country. It is the only faradaic apparatus here made, that yields only the *extra current.* It is most profoundly penetrating and chemical acting. It thus is capable of being a most efficient

aid in coldness and paralysis; for quickening the circulation, and thoroughly electrifying, and polarizing the nerves and muscles; for arousing from local palsy, or from suspended animation. Although so powerful, it is completely controllable.

Fig. 64.

The strength of the *inducing* battery regulates the activity of this apparatus in a degree, and is much like the French battery made by Grenet. The pair is composed of carbon for the positive pole, and zinc amalgamated with quicksilver for the negative pole; while the charge is a solution of the bichromate of potassa in dilute sulphuric acid. The solution is made thus: First, take out the pair, and place it in the receptacle, which is a lead cup. Pour into the glass battery-cup about six ounces of water, (or two thirds full,) and to this add one ounce of clear sulphuric acid, (two to four table-spoonfuls,) and add two drachms of powdered bichromate, (a tea-spoon even full.) Now, this is a powerful charge, and entirely unsuitable for many cases; one half, or one quarter, the acid and bichromate, or less, is all that is required for the painful and more delicate cases. As soon as possible, after use, remove the pair, rinse it, and place it in the lead receptacle, and close the battery-cup water tight. It is thus safe to carry in the carriage, or to take in the hand to the bedside. When the solution becomes green, or blackish, it is to be thrown out. When a new solution is made, it should be cool before putting in the carbon and zinc amalgam pair. Thus it is always ready for use.

Medical electrical faradaic apparatus are thus variously provided with a galvanic or primary battery of more or less power and persistence. The helix, or coil of induction, also greatly varies in quality and power; but as an *inducing source* for faradaic machines, probably the Smee battery is the cleanest and most persistent; but Hall's "*Petit*" *battery* is unquestionably the most portable and most powerful, for this purpose, of any made in this country. Apparatus fitted to run with a *Berzelius* battery, "of copper cup and zinc cylinder," the fluid of which being a solution of the sulphate of copper, commonly called blue vitriol, and now probably more extensively in use in our country than any other medical battery, answers very well, with the exception that it is very soon oxidized, and requires cleaning every time it is used; but the solution of blue vitriol can be allowed to remain in the copper cup from week to week as long as it is good.

For *aura*, or *shock*, therefore, we employ the friction glass plate, or cylinder machine, producing from the atmosphere static electricity.

For obtaining the *primary current* for chemical action, and for polarizing nerve-trunks, as from a compound galvanic arrangement, we use a Daniell's or Legendre's, or Smee's compound battery, or a Pulvermacher chain.

For producing *galvanic heat* for cautery, &c., we employ Grenet's one grand cell, or Grove's dozen cells, or Bunsen's half dozen cells, as a battery *for heat without intensity*.

For a *local alterative*, and chemical action of moderate degree, as for healing old ulcers, &c., we use the little Humboldt battery, as made by T. Hall, 15 Bromfield Street, Boston, and by Dr. Kidder, 483 Broadway, New York.

Thus we see that for *inducing* the more common and intenser secondary current, or the extra current, as through the helix of some sort of faradaic apparatus, we may employ a Berzelius, or Ruhmkorff's, or Grenet's, Legendre's, Hall's "*Petit*" *battery*, or Kidder's, Smith's, or Neiff's chemico-electrical arrangement; or the multiple horse-shoe magneto-electrical machine, according to the particular end to be attained; and sometimes resorting to either, as it may be our only choice, in a moment of extremest necessity.

### *Magneto-Electricity.*

*Magneto-electricity* is a term used to designate certain induction currents from other induction currents called *electro-magnetic*, — these latter being produced by the electro-magnetic machine, while the former are produced, on the contrary, by permanent magnets which are called magneto-electric machines. This, too, was the result of Dr. Faraday's profound researches. He found that if the poles of an ordinary horseshoe magnet be *approached* by one of the ends of a copper wire, that is thoroughly insulated and wound like a helix around a wooden spool, then the needle of the galvanometer which is in the circuit is immediately deflected, but that the needle soon comes again to rest. This, he observed, was repeated also when the end of the wire was *removed* from the pole of the magnet, and that in the opposite direction; and then again the needle soon came to rest. This indicated that an instantaneous current of a given direction is produced when the wire of the helix *approaches* the pole of the magnet, — and that this is repeated, but in the opposite direction, when the wire is *receding* from the magnet. For producing a succession of shocks, so as to make up a current, the magnet, or else the wire, must be regularly approached and withdrawn in quick succession. To bring this about in the most effective and practical manner, there is hung upon a shaft a soft iron *armature*, that is wound on both arms with a long coil of copper wire for induction, and this is set in revolving motion near the poles of a large and fixed permanent magnet by means of crank, wheels and gearing. This is kept in lively motion by some person turning the wheel, the which turns the armatures some eight times around to its once, and the armatures thus passing the poles of the magnet twice to every turn of it, makes some sixteen shocks to every turn of the crank. Every time the armature coils approach and pass the poles of the great compound permanent magnet, the soft iron armature is magnetized and demagnetized, and thus two momentary currents of electricity are educed, — the one at the instant of approaching

and magnetizing, the other at the instant of passing off and demagnetizing.

The magneto-electric machine is heavy according to its power; but it is in a box, compact, dry, and neat. Its inten-

Fig. 65. Magneto-Electric Portable Machine complete in its Box.

sity depends, first, upon the power of the great magnet, whether single or compound; second, upon the size of the wire that is wound around the armature, and also upon the number of its convolutions; third, upon the exact nearness of the revolving armature to the tips of the poles or arms of the great magnet; fourth, and finally, upon the velocity and regularity with which the wheel is turned.

In this machine it is easy to arrange a spring cut-off on the large shaft of the armature so as to strike an alternate cog of brass and ivory, and thus to effectually intercept *one* set of the shocks that make up a one-way current, leaving the other to pass to the electrodes, as a current made up of fine shocks or bits of currents, but *all in one direction*. This can be demonstrated by showing decomposition of iodide of potassium or starch only at one pole. Thus we have not only an induction current with a nominal pole, but here are the positive and negative poles *truly so* in effect.

The most wonderful magneto-electric machine, of which we have heard, is the apparatus arranged by Mr. Henly, of England. In his machine there are arranged two banks of per-

Fig. 66. Magneto-Electric Machine, showing its revolving Double Armature.

manent magnets, each of which is two feet and a half long, and five inches broad; each is made of extra steel, which was long and laboriously hammered. The induction coils on the two arms of the ponderous revolving soft iron armature contain some *six miles* of insulated copper wire, and all this is driven with great velocity and regularity by machinery and steam power. It is said that the electric power of this apparatus far exceeds that of Rhumkorff's coil; for the current obtained from the former is readily sufficient to kill a man or an ox instantly.

The physiological effects of magneto-electric currents are produced on making, as well as on breaking, the circuit; but the latter are stronger than the former, yet not to so great a degree as between the make and break in the battery circuit of the electro-magnetic currents. Therefore, when employing Faradaic currents for physiological and therapeutical purposes, we are allowed to take into the account merely the strongest current, i. e., those induced on opening the current of the battery in electro-magnetism, or on demagnetizing the armature in magneto-electricity.

*Magneto-Electric Machines.* — The *double* induction, discovered first by Professor Henry, of the Smithsonian Institution, which had never before been applied to magneto-electric apparatus, gives it a vastly increased power, when thus constructed, as they should be, with double coils on the revolving bobbin. The simultaneous intermissions of the magnetic current, and that of the central helix, produced by the rotary movement of the wheel, which puts in action the armature and the commutators, develop phenomena of induction in the wire of this central helix. Then, at the instant when the induction is produced in the central helix (first order) under the influence of the temporary magnetic current, if the conjunction of the two ends of the fine wire of the second coil (second order of current) make of it a closed conductor, there is developed in this latter a counter current, the direction of which is in an inverse relation to that of the first, coarser coil. There should be buttons leading conductors from both these coils respectively. The induced current from the inner, coarser coil is of moderate conduction. That from the outer, finer, and longer wire is far more intense, and capable of overcoming still greater resistance, and penetrating the deep parts more profoundly.

Finally, can we employ this magneto-electric machine and the galvano-magnetic battery indiscriminately, in all suitable cases, for electric treatment? No, by no means. The *magnets*, and other apparatus, may be thus used for cold, chronic rheumatism, callosities, and where there is a lifeless and insensible condition; for anæsthesia and paralysis without existing irritative lesion, and without a painful or excitable state of the nervous system; for cases of suspended animation, and for a rallying power generally, in all cases of haste; but it must never be long continued without more or less intermission.

We observe, then, that *Galvanic* currents differ from *Faradaic* currents in the following respects: —

First. The former are continuous and in one direction; the latter are always in interruptions, and these in rapid alternate directions; but as the terminal shock is stronger than the initial shock, so, when taken together, they make a stronger current in

that direction; and hence we call one positive, and the other negative; which, *in effect, holds true when acting on and through living tissue.*

Second. When the decomposition of water is brought about by the galvanic current, the hydrogen appears invariably at the negative and the oxygen at the positive pole. But if we decompose water by Faradaic currents, this is not the case, as each pole is *alternately* serving first for the positive and then for the negative pole, in rapid alternations, so that both hydrogen and oxygen appear at both poles. If these induction currents succeed each other very rapidly, it may even happen that both gases appear simultaneously at either pole, and, both being in a nascent state, they combine again so rapidly to form water, that the result is as if the water was apparently not at all decomposed by these induced currents.

Third. Another evidence that the Galvanic current and Faradaic current are not alike, is, by bringing a solution of the iodide of potassium and starch into the circuit of each; for then the blue color that indicates the liberation of iodine will shortly but moderately appear at *both* of the poles of Faradaic currents; while by the Galvanic current we notice the blue color quickly, and *only at the positive pole.*

### *Magnets as Remedy.*

"*Loadstone*" and Magnets have for centuries been supposed to have some influence on the human body, particularly in disease; but it has always been in the absence of any tangible demonstration. Professor Faraday submitted his own body to the trial, by Dr. Keil, — who, at the time, was advocating those views, — with most powerful and formidable permanent magnets, but without any appreciable result. M. Pereira states, that as early as the days of Ætius, which was in A. D. 550, it is recorded that this then marvellous "*loadstone*" was bound upon the sick part. Dr. Alfred Smee has pursued a series of experiments for investigating this matter to some satisfactory result. He

placed the web of a frog's foot, and then the tail of a fish, under the field of the microscope, and there exposed them to the influence of very powerful magnets, but without producing the slightest effects upon the circulation of the blood, or upon the capillaries. He says he has also subjected the various organs of sensation to its influence, but never has been able to produce the slightest effect upon the eye, ear, nose, tongue, or skin. Nor was he more successful in his experiments on cell life, for all these trials gave negative results. From such trials, by one so competent, we may safely infer that terrestrial magnetism either has no kind of influence at all over the functions of *animal* life, or is so limited as to be usually an exception rather than a rule.

The "*horse-shoe*" magnet has also been resorted to as a remedy during the past century, and the result is, that both the natural and artificial magnets are claimed as peculiar and positive remedies for *gout*, *spasms*, *convulsions*, *epilepsy*, *tremors*, *cramps*, *neuralgia*, *rheumatism*, *palpitations*, *neuralgia of the heart*, *and true angina pectoris*. Persons affected with spasmodic diseases — epilepsy, catalepsy, chorea, paralysis, and hysteria — are said to be especially sensitive to this influence. It is on the nervous system that the magnet is claimed to exert its efficacy, and is applicable mainly to the nervous and spasmodic. While some it cures, a large proportion are not affected by it!

*Method.* — The chosen kind of magnet — of ten pounds, more or less, supporting power — is generally applied to or about the diseased part, and thus moved or maintained for a longer or shorter time, according to the case. From time to time it is drawn slowly along, close to the skin, over the course of the nerve that leads to the affected part. At other times, as for toothache, it is applied stationary against or near to the part. The celebrated Dr. Laënnec, who employed the *magnet remedy* in the treatment of lung diseases, according to the manner recommended by Hallé, i. e., by maintaining a magnetic current through the diseased parts, by means of several magnetized plates, affirmed that he "frequently found it to moderate the pain in pulmonary neuralgia, to diminish the oppression in

nervous asthma, to suspend spasmodic cough, and to control neuralgia of the heart." The author, however, has witnessed the application of true magnetism, by means of mineral magnets and by powerful steel magnets, for nervous diseases, in persons of highly impressible habits; but except in such, and apart from *the effects on the mind*, he is of the opinion that there is no physiological or remedial result; and these are the views of highest authority.

### *Æsthesiometer.*

For the purpose of aiding in the diagnosis of certain forms of nervous diseases, Dr. Sievking constructed this little instrument, by whom it is at length described and recommended.* Its employment is based upon the principle, that the *capability of distinguishing the distance between two points*, applied exactly and simultaneously to the skin, at different parts of the body, varies with the tactile sensibility of the respective regions. This power, in health, always follows the general *laws of symmetry* that we find governing the body.

The absolute impairment of tactile sensibility may be ascertained by comparing a given result with the tables of Professor Weber, which are now contained in most new books on physiology. Thus, if a person in health is able to recognize, as two distinct impressions at the tips of his fingers, points of only one tenth of an inch apart, it follows, that if we find him *unable* on *one* or both hands to distinguish, say more than four tenths of an inch apart, then there must be a serious impairment of nervous susceptibility to the *reception* or *conduction* of tactile impressions.

The *nature* of the impediment must, of course, be determined by other evidences. But here it is manifest that, by applying an instrument to measure the exact tactile sensibility of different parts involved, or supposed to be involved, in a paralytic affection, we secure a more trustworthy standard, so far as it goes, to judge of the profoundness or extent and character of

* British and Foreign Medico-chirurgical Review, 1858, p. 280.

the affection than if we trust to the patient's description of sensations, or simply to the ruder mode of pricking or pinching the skin, as heretofore employed. There are three classes of circumstances in which the æsthesioscope, or "dividers," may be usefully employed as a help-diagnosticator: —

1. In suspected actual paralysis, to determine the amount and extent of anæsthesia.

2. As a means of diagnosis between actual paralysis of sensation, and mere "subjective anæsthesia," in which case we know the tactile powers are unaltered.

3. As a means of determining the progress of any given case while under electric treatment, or where waiting for treatment, whether for the better or not. Now, it would be superfluous to give illustrations of all these three classes of cases, showing where this might afford us some assistance. The first and the third speak for themselves, and to obviate any misunderstanding of the second, an instance is subjoined.

Case. M——, aged fifty-two, suffered, for six months before the first consultation, from numbness and *formication* about the left hand, with severe nocturnal pains along the tips of the fingers, and at their metacarpal ends. The patient rarely had pain in the thumb, and none in the palm of the hand. There was frequent vertigo. Now, to determine the character of this numbness, the æsthesioscope was tried, and the patient was found to be able to distinguish one tenth of an inch equally well at the tips of the middle and third fingers of both hands; i. e., of the sick hand as well as the well hand. The instrument therefore aided in the determination of the diagnosis, by showing that the *sensation* of numbness was purely subjective, but doubtless originating in the encephalon, as does *tinnitus aurium*, yet not the actual result of a true paralytic affection.

Fig. 67.

This instrument is essentially what is known to mechanics as a "beam compass." It consists of a square rod of brass, four inches in length, graduated and marked into inches and tenths of inches. At one end of this is a fixed point one inch long projecting at right angles, while another such point is arranged so as to slide along on the graduated beam, much like a shoemaker's measure. Certain precautions are necessary here in order to insure trustworthy results. And, first, *it is important* that the patient should not know what is expected; therefore he should not know *why* the instrument is applied; and the points should not be seen by him, so that the eye may not influence his answers to the tactile impressions. It is of all importance, moreover, to make the two points to touch the skin exactly at the same time, or there will thus be produced two successive impressions, which would alter the value of the result. We may use a pair of common dividers, or carpenter's compasses, in the same way and for the same end.

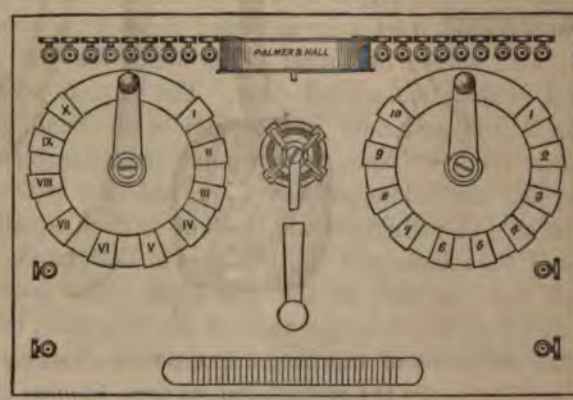



Fig. 68.

*Key-Board, or Manipulator.*—This is a very ingenious instrument, contrived for bringing any number of batteries into circuit at pleasure, from one to one hundred cups. It is arranged with a pole-changer, break-piece, and key. This is a very desirable instrument, when the constant current is used, as it places the battery in perfect control of the operator.

# ELECTRODES OR POLES FOR MEDICAL PURPOSES.

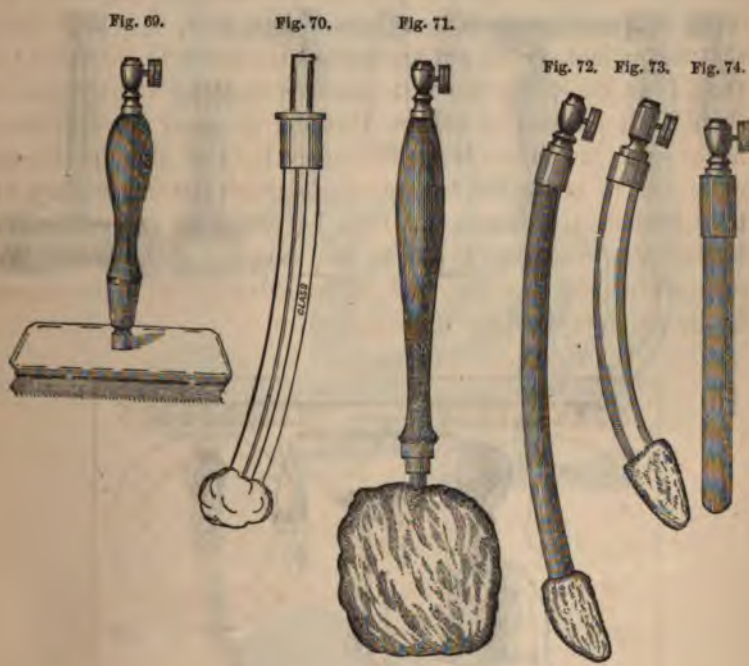



Fig. 69. Wire Brush Electrode for some local Faradization. See Fig. 88.
" 70. Sponge-tip Glass Electrode for Vagina.
" 71. Large and fine Sponge Electrode for general purposes.
" 72. Gutta-percha Flexible Electrode for Face, Mouth, and Fauces.
" 73. Gutta-percha and Sponge-tip Electrode for Uterus and Rectum.
" 74. Metallic Electrode, heavy silver plated, oval tip.

N. B. No electrode should be used the second time without having been perfectly cleansed. This is done for the sponges, in the first place, by warm water and soap; then rinse, and pass them through dilute *liquor sodæ chlorinatæ*, one ounce to a quart of warm water, allowing them to remain in it for a time; then rinse them again, when they will be perfectly sweet and bright, as if new.

Fig. 75. Fig. 76. Fig. 77. Fig. 78. Fig. 79. Fig. 80. Fig. 81. Fig. 82.

Fig. 83.

Fig. 75. Electrode for the Ear, and other delicate purposes.
" 76. Electrode for Throat and Fauces.
" 77. Electrode of Silver, for the Tongue.
" 78. Handle Electrode, half insulated.
" 79. Handle Electrode, and Metallic Hollow for Sponge.
" 80. Glass Electrode for the Eye.
" 81. Ball Electrode covered with Wash-leather. There are *three sizes* of these, for placing over nerve-trunks.
" 82. Large fine Sponge Electrode with Glass Handle.
" 83. Duchenne's Exciters — Electrodes.

Fig. 84.

Fig. 85.

Fig. 86.

Fig. 87.

Fig. 88.

Fig. 89.

Fig. 84 is a view of my *Swivel Electrode*, for passing down inside of the dress of ladies, for the back, stomach, or bowels. The pad is metal, covered with buckskin, to be wet.

Fig. 85. — *The Egg and Stem Intra-Uterine Galvanizer.* The egg is made of fine silver, the stem is all of zinc, insulated one third of its length.

Fig. 86. — Improved Conductors, covered also with rubber tubing.

Fig. 87. — A view of my Electrode attached to the conductor, simply by means of the elastic tube, without binding screws.

Fig. 88. — The *Wire-Brush Electrode*, for *localized Faradaization.*

Fig. 89 (and 87) are views of *Garratt's Spoon Electrodes*, composed of a rubber, spoon-shaped insulator, lined with metal, and fitted with sponge; used for most general applications of electricity. Made by T. Hall, Boston.

Fig. 90. — The *Handle Electrode* for holding either of the tips Figs. 91, 92, 93, 94, 95, 96, for galvano-cauterization. By moving the thumb-block the current is let on or shut off instantly.

Fig. 97. — *Foot-Board*, or *Current-Breaker*, for dentists' use.
Fig. 98. — *Electrode Slipper*.

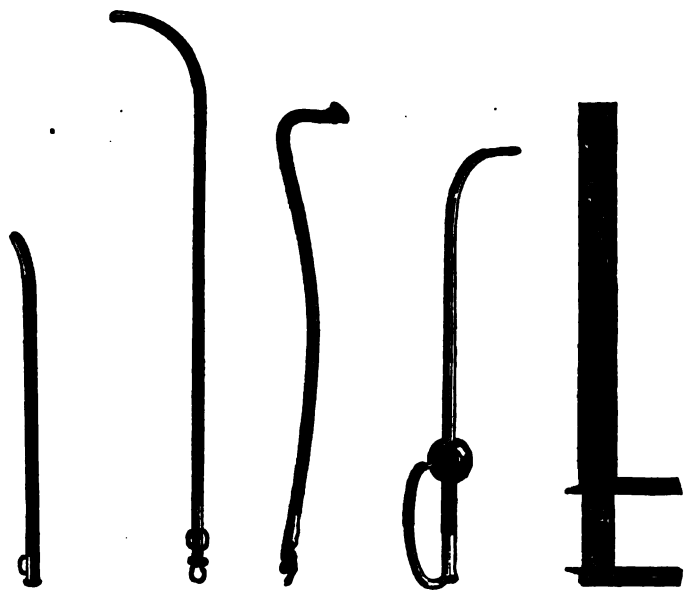


Fig. 99. Fig. 100. Fig. 101. Fig. 102. Fig. 103.

Fig. 99. — Insulated Female *Catheter Electrode.*

Fig. 100. — Insulated Male *Catheter Electrode.*

Fig. 101. — Insulated *Flexible Electrode,* with gold tip, for reaching the opening of the eustachian tube from beneath the palate.

Fig. 102. — Insulated Electrode, for electrifying the pharynx, glottis, or *chordæ vocales.* The end of the handle springs into a socket, to make and break contact.

Fig. 103. — Æsthesiometer, to aid in the test of lost sensibility.

Fig. 104. Fig. 105. Fig. 106. Fig. 107. Fig. 108. Fig. 109.

Fig. 104 is a view of my ivory and sponge *Ear Electrode.*

Fig. 105 is my Insulated Camel's-Hair *Flexible Ear Electrode.*

Fig. 106 is a delicate *Sponge-Tip Electrode,* for the eye.

Fig. 107 is also a very small sponge-tipped Insulated Electrode, for localizing accurately, as over a nerve-trunk, or for tracing small muscles. Figs. 108 and 109 are also for similar uses.

# CHAPTER V.

## METHODS AND RULES FOR THE MEDICAL AND SURGICAL EMPLOYMENT OF ELECTRICITY.

*Alere flammam vitalem et morbo mederi.*

### *Electricity as a Remedy.*

In laying down precise methods and rules for the use of electricity as a medical and surgical agent, I shall, in this chapter, consider it only in relation to its physiological and therapeutical effects, and the conditions which are necessary to obtain a definite and reliable result. As these effects and results are materially modified by the *mode* in which the given electricity is developed, as well as by the *methods* of application, it will be inferred at once that a good and efficient apparatus, of a given class, that is also adapted to the given class of affections, is almost as important as the knowledge and skill of the operator.

The galvano-magneto-electric machines of the faradaic class, probably, meet the greater number of indications. In this class we might mention *Hall's Constant Smee Apparatus*, *Hall's* more powerful "*Petit*" *Battery*, *Kidder's Chemical Apparatus*, New York; *Apparatus of Neif*, Philadelphia; *Clark's*, London; *Ruhmkorff's*, *Dujardin's*, or *Grenet's*, all of Paris. But there are numerous other classes of cases that can be better, and more successfully, reached by static electricity, or by primary galva-

nism, as from a *Daniell's*, *Bunsen's*, or *Grove's* compound battery; or by that excellent primary and secondary one of *Legendre* and *Morin*, of Paris; or by the compact multiple single element of *Grenet*, for heat and cautery; or by the Pulvermacher chain, or the little *Humboldt battery*.

### *Precautions.*

First of all, it is necessary to bear in mind that there is the greatest conceivable difference in individuals of the same age and sex as to their *susceptibility* to the effects of all electric currents; and these form *two classes* of patients. The first are those where there is *exalted sensibility*, and where only the most gentle procedure, and that with the most feeble currents, is at all admissible. In this class we may also include those with exquisite susceptibility to the *in-working* and also *reflex action* of the current, and that without their suffering, or even scarcely noticing it, during the *seance*.

The second class of persons are those where there is neither anæsthesia or paralysis, and yet there is a very marked indifference to the attempts of the currents. Some do not feel even the stronger currents; and others do not receive, or rather give no evidence of receiving, any impression from their in-working. For such reasons, great precaution is necessary in the employment of electric currents, particularly in giving the first *seance* for a new patient, until we study the temperament; even then we cannot always be quite sure that the patient will bear, or need, in the evening, what he took in the morning.

Accidents from the indiscriminate use of electric currents, or from carelessness in their use, or where absolutely injudiciously applied, as to the case, the length of time, the strength of the current, or the direction of the current, are real and serious. When it is not managed so as to produce good effects, it *may* be doing an evil work. Indeed, the very same current that is not only harmless, but beneficial, for one, to another of the same age and sex may prove so powerful as to be actually injurious, or so inadequate as to be quite inefficient. There may be produced, then, from too strong a dose of it, or too prolonged use

of it at a time, a bruising, or soreness, or fatigue, or exalted irritability, a neuralgia, or even cerebral congestion and hemorrhage. Now, some of the *slighter* of these effects are possible to be produced at the most prudent first *seances;* but in such a case the difficulty can be easily eradicated by treating it at the next time as an original and independent derangement.

The author fully believes that where electric currents are applied to the patient *without regard to the laws of their action on living tissues*, they may by chance produce, instead of amelioration or cure, an actual aggravation of the acute or chronic malady, which degree may remain (as he believes he has seen unmistakable examples) equally as persistent, as a correct use of the same currents will cause improvement, (by producing the opposite polarization of the nerve-fibrils and muscle-fibres,) or even a complete restoration, that is also persistent. These are no imaginary evils. Scarcely a week passes but some poor invalid sufferer presents for examination or treatment, who dates the "*growing worse*" from a given time, when "galvanized" by some ignorant person who applied the currents so shockingly, perseveringly, or repeatedly, that the hands were cramped, the muscles pained, and the limbs tetanized. *From that time* the paralysis was greater, or the pain along the course of the nerve trunks more acute, the aches in the joints more profound and unbearable, or the contraction of the limb more persistent. The would-be doctor may give bread pills for *placebo*, or dabble with ipecac, rhubarb, and saffron, but *never* with the contents of the surgeon's case, nor yet with the currents of electricity.

Before commencing the treatment of a new case, it is well first to ascertain as near as possible the extent of the pain or palsy, deficiency or deformity of the muscle or limb. I usually make a record, for example, of the angle of the tonic contraction — of the coldness or heat of the limb — of the height to which the patient can raise the hand or arm laterally, or in front, as well as behind the back — measure the *atrophied limb* very carefully, and ascertain the precise character of pain or remaining sensibility and muscular response to various stim-

uli. In the lower limbs, in case of sciatica, rheumatism, palsy, or spasmo-paralysis, it is important to find the angle the thigh can make on the body — how far apart the patient can separate his feet, or his knees, by his utmost effort, &c. Thus to scrutinize severely, *in the commencement* of each case, the minutest peculiarities, and the degree of these, for the correct application of galvanic or faradaic currents. Although unable to produce an improvement in some cases, yet in others not unfrequently the very first five minutes may obtain a partial and *permanent* improvement that would not otherwise be credited.

Especially must we always bear in mind the great difference there is in persons as to susceptibility to the influence of the *different* currents; and for that reason alone we should begin very gently, and make the first *seance* as short as the obtaining of some given end is had. Some persons, we find, can bear the most powerful and frequent applications of any form of currents without experiencing any after-workings; — while there are many others, who, after a single active trial, experience chills down the thighs, or drowsiness, or even lassitude. But others more frequently find from it a most refreshing sleep, where they had not had such before perhaps for months or years. Even an inability to sleep may appear in others after the first few sittings; but this usually gives way finally to most comfortable rest. By watching such after-workings we shall be able the better to regulate the frequency and activity of the *seance*. All these sensible by-workings and after-workings of the current appear only at and after the first applications, if the physician rightly graduates the strength of the current to the endurance of the case.

It is but a prejudice, and without any foundation whatever, to suppose that old people, little children, and extremely feeble persons, should not receive this kind of medication. Indeed, in my own judgment, these are the very persons to share in these blessings, only it must be adjusted to their endurance, kind of health, or derangement. Dr. Remak says it is his experience that the galvanic current is of the greatest value to aged and infirm persons, particularly for *prematurely old* men and women. He also

found it of very peculiar advantage to "*atrophic*" children. Probably this reference is simply to puny children, or to the marasmus, rickets, and scrofulous diseases of children.

The smart, prickling, or painful sensation of the current can, as a general thing, be a standard to guide us, or at least aid us to judge, as to how much the patient can or should bear. Yet we must bear in mind that there are cases, also, (as paralysis proceeding from the spinal marrow,) where the sensitive nerves are so utterly unexcitable that, although the entrance and leaving of the current causes the strongest contractions, the currents are not *felt* in the least. In such a case we must not proceed *trusting to this standard*, but refer to the number of elements, and to the galvanometer; or, if using induction currents, we must regulate the soft iron within the helix, or the battery power.

*Electro-medical Terms.* — Heretofore there have been much confusion and radical misunderstanding among medical men from the careless or ignorant use of terms, which has greatly retarded the knowledge and employment of electricity as a remedy. When reporting cases, and when giving the results of experience, one physician will speak of "*electricity*" without describing its form, or mode of application. Another will call the agent "Galvanic" or "Voltaic," or merely incidentally mention that the patient was "*electrized*" or "*galvanized;*" or perhaps only mention the apparatus; and one terms it "*electric*," another "*hydro-electric*," or "*volta-electric*." Another, speaking of his success, or failure, will say, with "*Galvanism*," or with "*Faradaism*," while his own account of the case, and the result of treatment, show conclusively that he was using exactly that form of the agent which he does *not* mention, and has *not used* that which he has mentioned. Here is a need of more knowledge, or more care and accuracy of expression.

A great variety of other ambiguous and compound expressions have been, and are, employed synonymously by medical men (many of whom, we have reason to believe, do know better) when reporting important cases of nervous or protracted maladies of the greatest interest, where cure, or relief, was brought about by some potent, hence *appropriate*, form and application of electricity of which deponent saith not.

From this cause nearly all that has been written on this subject as relating to practice, which would have been invaluable to the medical world, is lost; simply from the fact that we are not informed as to the exact *means* or *method* by which such favorable results were obtained. The consequence is, also, that very many medical men have vague ideas of a rational and scientific use of electricity, as a dexterous or skilful treatment, which should be accurately adjusted to the given case, as to quality, kind of strength, time, methods of manipulating the electrodes, kind of electrodes, current-direction, interruption, alternation, and the anatomy of the part involved in the affection that is to be treated.

In the gravest cases, sometimes, where faithfulness and skill are fairly baffled, electricity is thought of as a final resort and the only hope. Even here, too often, all that is precious in life, and that now lies in the trembling balance of suffering and safety, life and death, is submitted to any sort of an old or new, valuable or worthless, powerful or weak electric, magnetic, or chemical battery that may by chance be conveniently at hand, which is set to work "*applying electricity*" to the patient. Perhaps the case resembles one that had been reported, by some one, as "*cured by galvanism.*" Probably those ridiculous tin handles (electrodes) are placed respectively in the hands of the patient, so that the current runs up one arm, across the chest, and down the other arm; or one pole is placed stationary at the back or stomach, or is put into a tub of water together with the patient's feet, while the other pole is held in the hand of the patient; or it may be the doctor in this case "allows the current to pass through himself to vitalize the patient," — while the current, of whatever form, is all the while running, perchance, this way or that, — and this is considered, by many, as applying electricity! The patient is sometimes placed in a water bath, in a metallic tub, one pole in his hand and the other in the water, — this is termed an electro-chemical bath, — and so he sits, or lies, and takes the empirical dose of power, *haphazard*, for a half hour or so, no matter what be the disease. Of this, in the report of the case, it will be stated, "*electricity was tried.*" The result,

of course, is usually a failure; and though favorable in some rare cases, yet more frequently there is actual injury. Faith is lost. Resort to this agent, as aid in medical treatment, becomes rare; that is, it is resorted to only in desperate cases. How ridiculous all such bungling empiricism and quackery! What an abuse of means!

After all, it is my profound conviction, the result of many years of experience in the practice, that no one medicine or remedy in all the range of therapeutics can meet so many indications, and accomplish so much good, particularly in nervous, vascular, and chronic maladies, as does electricity, when proper cases only are subjected to it, and the applications are judiciously conducted. But, in a more just and truer sense, what an invaluable power it becomes, *as an aid*, in the hands of the intelligent and skilful practitioner, where it is made to be an intelligible co-worker with all other reliable remedies, coming years will surely testify.

*General Propositions.* — The first question that arises here is, where, and when, and for what practical indications, may electricity, as a therapeutic, be considered as indicated? By standard works on therapeutics, as Wood, Stillie, and others, we are justified in the following general propositions: —

1. To *stimulate* peculiarly and especially, by a given appropriate form of electricity, parts in which sensation, or the normal power of motion, may be defective or wanting; as in paralytic conditions of muscles or muscular power, or of general sensibility, or of the special senses.

2. To *correct* deranged sensations; which includes the quelling of pain and distress; to tone the cords and muscles, as well as to relax excessive contractions, as in some forms of neuralgia, rheumatism, &c.; to alter morbid nutrition by electrolysis and catalysis; to effect through its chemical agency a local coagulation of blood, as in aneurism and varicose veins; and to renovate simply exhausted nervous and vital forces, and to cauterize nerves and sanguineous growths.

3. To operate *revulsively* on the nerve-centres through the medium of the skin-nerves, as in various internal and profound

affections, even including some chronic inflammations, congestions, and organic plethora and rheumatisms; thus to promote digestion, or any of the secretions; or peristaltic action, absorption, and circulation; or to equalize animal temperature, as from the head to the feet; as also the nutritive and depurative processes, especially when electricity is directed to the flagging vital properties; also to awaken a keener susceptibility of the system to the action of other medicine.

4. To awaken the system generally, as in asphyxia, syncope, and from the poisonous effects of narcotics; and to recover from extreme exhaustion, and to arouse from suspended animation.

*Methods for employing the various Electric Currents.*

In the more recent German and Italian medical writings we find evidence that some leading men there are giving more special attention to this particular department of "*therapeutics*," than we find either in France, England, or America. Dr. Duchenne, however, was the first to partially recognize the great fact, *that there are certain spots along the surface of the body and limbs that give very peculiar response to the electrode in producing more ample muscle contractions without pain.* Simultaneously, and still more clearly, was this remarkable circumstance *discovered* by Dr. Robert Remak, of Prussia. He says, "After numerous trials on the different parts of living men, I am prepared to say that I believe I can explain those spots, or 'border points,' alluded to by Dr. Duchenne, as observed by him, but in only two muscles." In a very recent foreign work by Dr. Maurice Meyer, on "The Uses of Electricity in the Practice of Medicine," published in Germany, there appears the following description of his method: —

"*To produce electric excitement of the 'motory nerves,' or of the muscles, we must lay wet excitors with active induction currents on those points of the skin which lie as much as possible immediately over the said muscles.* We find that the surface muscles of the trunk, as well as those of the extremities, by operating in the manner thus prescribed, may easily be made to *contract;* while many of the deeper lying muscles may be

reached in the region of their *source*, or of their concourse,—*for there are such places*,—where they are peculiarly accessible to the direct in-working of the electric current. Where this is not the case, we must apply a more intense current, or have recourse to *Indirect Faradaization*, which, though probably less efficacious, either as effect or as remedy, is, however, here to be preferred." No mention whatever is made of placing the electrodes with reference to the oblique course of the fibres of the muscles, nor yet is there any allusion to the action obtained as being through the nerves, but direct excitement is plainly inferred. The fact of muscle *border points* has here too, doubtless, been observed; but its bearing for practice was not discovered.

I have elsewhere said — and it should be particularly borne in mind — that all persons are not in a like degree susceptible to the influence of the various electric currents. Not only does the application of the Faradaic currents show a surprising difference between one person and another, but I find that this can, and does, vary in the same individual from day to day; yes, even from morning to evening. This result of actual experience should have a place and bearing in the mind of every physician, as regards the widely varying susceptibility of different patients, and even of the same patient at different times, to the influence of a given dose of the various medicines, as well as to Faradaism or Galvanism.

There are cases, we know, where even the indiscriminate applications of small, wet electrodes to the surface of muscles, and with very moderate induction currents, such as are quite supportable by the sentient nerves, will sometimes produce a contraction of the whole muscle, or at least of the surface fibres of that muscle. This result is obtained most readily in proportion as the skin at that point is thin, and the muscle is also thin and lean, yet rich in nerve fibrils; as, for instance, on the muscle *trapezius*, or the *pectoralis major*. Here we can generally cause one or more bundles or layers to play at will, and this is the species of phenomena to which Dr. Duchenne refers, to prove the direct in-working of the Faradaic current through the muscle fibres, *independent* of the nerves; for he advocates the doctrine of Hallerian irritability.

### *Methods for using Static Electricity.*

Friction electricity has long been, and *still is, valued for arousing and increasing the vital powers where simply sluggish.* The author has found it of very marked advantage for some invalids *who*, after great sickness or calamity, *remain in a low state of health*, and yet present no discoverable reason why they should not get better, only that there is a low tone of the nerves and functions, that cannot be reached by medicines or regimen. For these patients, young or old, the positive *electric air-bath*, taken sitting or reclining in an insulated easy-chair, with the feet upon the insulating stool, for half an hour a day, and occasionally alternated by sparks *drawn*, is a rational and often successful remedy. The machine requires to be turned very *steadily* and *quickly*, while the chain or rod director from the prime conductor is held in the patient's hands. At the same time, see that ample provision is made for the escape of the negative electricity — i. e., from the rubber end of the electrical machine to moist ground, or to some mass of *iron*, if near by. This can be done by a chain leading from it to the water or gas pipe. A dry brick wall, we must remember, will not always do this well. Now, as the patient becomes more highly charged positively, the hair will rise; and should the room happen to be dark, numerous sparks and luminous appearances will be observed, because the atmosphere about the patient is rendered negative, as it always is about a highly positive body. I have repeatedly heard the patients say, in the course of five or ten minutes after the *seance* begins, that they are warmer, and feel exhilarated. The circulation is found to be decidedly accelerated; and the secretions, especially the perspiration, become more active and general.

To give the *negative electric air-bath*, we have only to change the conductors so that now the prime conductor connects with the earth, while that of the rubber must lead to the patient. This negative electric state *is said* to be an electric antiphlogistic, acting by depriving or drawing off from the organism its morbid accumulation. But we cannot see the reason, nor

can we corroborate these deductions from any experience, as in our hands the testimony on this point has always resulted negatively.

*Sparks* may be *given to*, or *drawn from*, any part of the body, but they can be most readily obtained on a dry surface; for if the skin or the patient's clothing is moist, the discharge is thus dissipated, and we get no spark. *Electrization* by this means has been greatly esteemed by some experienced physicians for its success in curing chorea, hysteria, colds, rheumatisms, some forms of paralysis, and neuralgia.

While the patient is sitting in the *insulating chair*, and charged *positively*, sparks can be *drawn from* the body by applying any conductor near to the patient. If the person is being charged *negatively*, the same manœuvre will *give* sparks to the spot where it approximates. In either case there is a vivid flash of light, which, so far as it goes, is a streak of lightning. This is always attended with the sound of a sharp crack, as the negative electricity instantly combines with the positive. The sensation of a spark on the skin is like that of a slight prick of a pin; and this pricking sensation is in proportion to the *length* of the spark, as well as according to the *sensibility* of the part. Hence it is necessary to proceed gently with this by holding the ball of the conductor *against* the skin, or *very close to it*, at the commencement, until the patient gets a little accustomed to its sensation, when the discharger may be carried farther off to give longer and stronger sparks, and produce a greater effect. Giving sparks does not have so much effect locally as *drawing* the less frequent but longer sparks; for this latter produces a local accumulation of high-tension electricity in the skin and sub-adjacent tissues near the spot where the ball approaches the body. Here is the simple and most true localization of electricity. This method of applying electricity for the sick has been much employed for many years as the most efficient and reliable remedy for given cases, by Dr. Golding Bird, in the "Electrical Room" of Guy's Hospital. The *method* there adopted was as follows: A brass ball-tipped director, (discharger,) with an insulating handle, was furnished with an adjustable chain, or large wire

conductor, which is put in thorough connection with the ground. This, I find, is more readily done by using a good-sized chain, — say half inch, and silvered, — with a smooth hook on its end, to be readily adjusted on the metal shank of the discharger, and passing the ball of the discharger gradually and wavingly, more or less close, up and down the spine, within about an inch or so of the surface of the body or limb. It is understood that the patient is being retained positively charged all the while, by holding the chain to the machine, that keeps up the supply to the body, which here escapes to the ball and chain, and so to the earth. By holding the ball very near the skin, the sparks are so rapid as to form a mere interrupted one-way *current*.

Shocks from the Leyden jar are much employed in Europe for *amenorrhœa* by directing the discharge through the pelvis of the patient, from the sacrum to the pubis. When it is desirable to discharge the shock through any given part of the body or limbs, and that in a certain direction, we use a double discharger — i. e., one with a glass handle, and with two arms, that may be jointed and adjustable, or not, but the arms are tipped with bright brass knobs. One of these knobs we bring in contact with the point or region where we wish the charge to *enter* the body or limb. Then, if the outer coating of the charged jar has been already made to communicate by a good and ample conductor which is adjusted so as to lead to the point of the body or limb where we wish the charge to *leave* the body or limb, and we cause the second knob of the discharger now to approach the ball on the top of the Leyden jar which communicates with the inner coating of the jar, the jar is instantly discharged through the part of the patient so positioned. If the clothing and person of the patient are moist or wet from perspiration, it will require care and no little adroitness to succeed.

Dr. Cavello early published a small essay on "The Uses of Electricity in the Practice of Medicine." He strongly urged then the use of the machine in cases of paralysis, poor sight from want of nerve power, nervous deafness, chorea, epilepsy, and for restoring those who had fallen into the water, as he had succeeded best in all these with friction electricity. Dr. Cavello's

method was, to *draw the sparks through dry felt* or flannel. The patient sits insulated as usual, and takes the chain to the prime conductor of the machine in his hands; a piece of perfectly dry flannel is placed over the part which is to be electrified; and, the machine then being put in action, the brass ball or knob of the director that is in connection with the earth is then brought in close contact upon the flannel, while it is regularly and slowly moved along the part affected, and thus made to draw a succession of minute sparks through the cloth, as, for example, along each side of the spine, over the roots of the compound nerve trunks, as they take their exit from the cord. We may sum up the uniform local effects upon the skin and underlying tissues, as being in direct proportion to the efficiency of the machine, the length of the spark, the repetition of these sparks, as well as the delicacy and sensitiveness of the skin of the part operated upon.

The *electric shock*, it is well known, is given from the Leyden jar; one or more being employed, according to the power required. It is also known that in this arranged jar there can be *accumulated* a considerable quantity of electricity of the highest tension, and that on a comparatively small surface. The jar can be charged either positively or negatively. To charge it positively, the brass knob at the top of the jar is made to communicate with the prime conductor of the electric machine, while the outer coating communicates with the earth; then some thirty to fifty turns will charge a one-quart Leyden jar.

### *Methods for using the Primary Currents of Galvanism.*

*Rule.*—When applying the *primary* current, or even the *extra*, or the faradaic current to any part of the body or limbs, for instance, and more particularly, when from ten, twenty, or fifty cups of Daniell's battery, *if it produces, or gives the patient, the impression or sensation of a coldness at the place where the electrodes are applied, or perhaps over a whole limb, which lasts for several minutes*,—provided this sensation is not the result of cold applied, as from cold water in the sponges,—then it may

be inferred that the nerves are extremely sick or feeble, near unto palsy; or, further, that there is actual disease at their roots in the great nerve-centres, and that this is *not* a suitable case to be so treated by primary galvanism. If *goose-flesh* is produced, we must come to the same conclusion.

But the foregoing test may often prove a capital diagnosis, which may guide us to the right future course and treatment. In such cases I always try again, by electrifying the skin and muscles smartly with a faradaic current; as it will not produce coldness in many of these same cases, but proves to be of the greatest service immediately; and indirectly, by quickening the system to a due susceptibility for the action of other medication. Thus there are cases where the repeated use of the faradaic current may be of the greatest service, even where the galvanic current, if it had been repeated or long applied, would have proved only injurious, if not quite disastrous.

Now and then we meet with an exception to the foregoing rule, viz., where the coldness is as fairly marked *at the first moments* of application of the electrodes, but which, in the course of a few seconds, *begins rapidly to change to a sensation of burning*. So that, in some such cases, if the coldness soon changes to heat or burning, we are not to give up the primary current, for it will aid the secondary in obtaining the cure.

A few remarks advanced by Dr. Duchenne some years since, in his great work on "Localized Electricity," respecting the inutility, and even "*danger*," of employing the primary galvanic current for medical purposes, have proved an effectual guard against its remedial use of late; so that almost no experience with the primary current has been obtained for the last ten years, excepting by a very few, whose testimony, however, is too high to be either overlooked or disposed of summarily. The first I will mention is that of Dr. Robert Remak, of Berlin, whose indefatigable labors and learned deductions command, at least, a respectful hearing. To understand this Prussian philosopher, we must observe that he is not a believer in the "*vis musculosa insita*."

According to Dr. Duchenne, "a *weak* and continuous current

of galvanism, when '*localized*' on the skin, will produce pains, erythema, and even blisters; while a stronger current will produce, when carried into the substance of a muscle, only feeble and irregular or uncertain contractions." This, at least, says Dr. Duchenne, "is the result of *an experiment* which I made on myself with a battery of one hundred and twenty Bunsen's elements. This constant current also produces the evidences of heat in the profundities of the organism, all of which phenomena are wanting if we use only fifteen to twenty elements." (!) In the fourth chapter he gives further proof by citing a case showing the workings of the steady current on the *retina*. It there appears that some kind of a new electrical apparatus was brought into his office by the inventor, while a patient was in the operating chair, suffering from a paralysis of the face. He thereupon made trial of this new machine, when, lo! the patient at once almost lost his sight. In the second case there also was brought in to him a new galvanic arrangement, (his own invention,) known as the "*Pile à rubans*," just as he was treating a patient for double-sightedness. When the doctor applied the current of this to the eyes of the patient, the latter jumped up, shook his head, and then exclaimed, "You have only *one* head! I no longer see double." This, in fact, is about all that we find from Dr. Duchenne on the physiological or therapeutical value of galvanism by a so-called constant primary current. True, he also mentions the fact that the constant current is less painful than the interrupted induction current, and as producing quick erythema, and even blisters. Speaking of the constant current apparatus which he employs for treating diseases of the retina, — *pile à rubans*, made of copper and zinc *ribbons*, moistened with the vinegar of wine, and hence extremely irregular in tension, — he says it (galvanism) is so uncertain in action, and so unmanageable, that it is quite unsuitable for other physiological or therapeutical purposes. Such are the amount and result of his experience, according to his own showing.

When treating of the physiological action of the primary current, Dr. Remak says, "I found from the multitude of my electric treatments, and especially from my experience with such patients as had been previously treated by some other surgeons

with the induction currents of magneto-electricity or electro-magnetism "*powerfully localized*" on the muscles, according to Dr. Duchenne's method, and particularly *in those cases of paralysis that arose from a central cause*, that although there were readily produced a plenty of tetanic or clonic convulsive movements in the affected muscles, by means of the *induced* (secondary) current, still they did not appear to restore the *voluntary* motive power; but, on the contrary, they sometimes evidently lessened this where it already had existed in some little degree, and that this *capability for voluntary action* appeared to be thus actually diminished by the strong induction currents, exactly in proportion as the given case of paralysis was depending at the time on a central source." (?) Subsequently, he treated alternate patients, in great numbers, by these two different kinds of electric currents; and the total results completely confirmed him in favor of the use of the primary current of galvanism, if used by a given rule, especially for those cases of paralysis, contractions, and fixed joints, *that depend upon an existing central lesion!* This, the greatest proposition of Dr. Remak, the author of this work cannot fully indorse; it savors too much of rash and unqualified statement, or of hazardous treatment; still, there is doubtless involved here a great physiological *principle*, that, we hold, should be watched and studied more and more, *as one of the very fundamental laws of both disease and cure;* viz., "reflex action."

Here I must also mention that we should take care not to ascribe the *absence* of sensation, absence of closing twitching, or absence of tonic contraction, to the *necessary want of action in the current;* and therefore it is of paramount importance for those employing the constant galvanic currents for therapeutic purposes to always include a galvanometer, or some kind of electrometer, as the galvanoscope, in the same circuit, so as to indicate *some*, but, better still, *the precise degree* of activity of the current.

As a general rule, I think the *comparative excitability* of *nerve trunks*, as uniformly shown by pain or contraction, appears greater the nearer the excited portion of the nerve lies to the brain. This holds good not only as regards single nerves, but it

is applicable to all the nerves of the human organism. Even with the motory nerves it appears to be a rule that here, also, the excitability decreases in proportion as it is made farther from the brain: thus tonic contractions can be produced on the human hand with so much the more facility the nearer the electrodes are placed to the brain over the trunk of the nerve *medianus* on the upper arm.

*Wavy current workings* are those that are produced by means of small metallic electrodes covered with wet wash-leather, flannel, or linen, and which are either hitched along over the surface, say every five seconds or so, on and in the course of the nerve, or held *more-and-less* firmly against the skin, so as to cause in either case frequent or constant changes in the density of the current. This method wakes up nerve-action.

*Steady current workings are those used for down-toning* — i. e., for purposes exactly opposite to excitability. For this purpose we must always choose *large*, soft, and moist electrodes, which must be gently and very gradually applied, and then held with an even pressure and moderate current, and then removed again, after the time, say from one to five minutes, with the same degree of precaution. This method calms the nerves.

There is a nice difference, also, to be observed between the *entrance* and *leaving* muscle contractions and the *closing* and *opening* contractions. These first, as we have seen, occur at the instant the current of the battery begins to course through the nerve and flesh; while the others occur at the instant the current is interrupted, opened, or broken, (as these latter terms are synonymously employed.) But the term "*entrance contraction*" refers to the putting on the electrode, *while* the current is still running, and the term "*leaving* contraction" refers to the removal of the electrode *while* the current is still running. On the other hand, the term "closing contraction" refers to the *closing* or making the circuit, as by the metallic switch contact of the key-board; and the "opening contraction" refers to the *opening* or breaking of the circuit by opening the same metallic key of the key-board. The latter division *is stronger in effect* than the former, probably because the electro-tonic state is more

readily induced by the very sudden change, than by the more gradual application and removal of the electrode. Therefore we obtain a rule in practice, that where we wish to *tone up*, or produce *increased excitability*, the quick, metallic making and breaking of the current is best. Also, for this, the choice of a brisk current through hard, moist, and moderate-sized electrodes is best. While, for *toning down*, the gentle putting on of the electrodes, and taking them away again after a *more lengthy* application, and this while the even current is still running, is always to be preferred; so, for this end, we should also choose the large, fine, and softest sponge electrodes, and employ the most gently managed, even, and moderate current.

We shall sometimes find that we can obtain, even from a medium *labile working*, a moderate degree of down-toning in abnormally *exalted* nerves. But we must not be too confident that the *stabile in-working* of the constant current through a nerve produces, by the induced electro-tonus, a diminishing of capability or of sensibility under all conditions and to any extent. Rather will we meet, in practice, with the more uniform facts that invite us to the view that the reëstablishment or the increase of the somewhat existing *electro-tonus* in the nerve fibrils and muscle fibres, by means of stabile currents, is the very best means for bringing the nerves into a condition most suitable for the normal or natural conduction of both peripheral and central impressions.

It is now ascertained, as I am inclined to believe, that the *current variations*, even when small, are sufficient to produce changes in the density and uniform direction of the native nerve current, and are more powerful and effectual to arouse an increased susceptibility in the nerve, for the future working of the applied current, than the *steady* in-working acting even for a longer time. Our experience also teaches that the increase of susceptibility in a nerve, appearing at a *wavy* in-working, is seen not only at the entrance and leaving of the same current, but even with a weaker current; so that, for instance, where a nerve is not susceptible to the action of a given primary current, — say from ten elements, — yet it will be made to acquire this aptitude

after a short in-working of forty, then thirty, then twenty elements, for a few seconds each, so that the nerve will now respond promptly to the ten. This increase of excitability, brought about by the current, is most easily traced, for example, on the muscle *biceps*, or on the facial muscles. We therefore lay it down as a *rule*, that a current which at first, as in cases of palsy, produces neither an entrance or leaving contraction, can be made to show it after having an in-working for thirty to sixty seconds of the same current strength, and this all the more prompt the longer the current has so worked. Indeed, very similar results as these last are obtained when, in the same manner, we use the *induction* secondary currents of *fine* vibrations as if a primary current.

From the repeated results at the electric *seance* of paralyzed patients, we find that the previous employment of say a half-quantity induction current, — that is sufficient to produce muscular contractions, although the electrolytic action of this, as shown in the galvanometer, being nearly at zero, — increases the susceptibility of the nerve and muscles for the after in-working of the constant primary current, certainly as far as that is shown by pain, redness, and twitchings at the entrance and leaving of the current. Furthermore, we find that the susceptibility of the muscles and nerves to the action of induction or Faradaic currents, and to constant or Galvanic currents, is about the same; but there are cases among healthy persons, and others still more marked among the paralytic, where the action of this current or that, decidedly prevails.

It is but a natural query, arising from many observations of Galvanic and Faradaic treatments, whether the change thus produced in the *electro-tonus* of the nerve and its depending muscles does not play an essential part in those cases where are shown the most wonderful and otherwise unaccountable curative effects of the various electric currents; although it is more in harmony with our present knowledge, and the prevailing opinions, to say that the *electrolytic* working of the current produces the restoration.

"*Volta's Alternatives.*" — We look upon these manœuvres, in given cases, as some of the most powerful means we possess for

producing an in-working of the current in the fibrils of the nerves, and, in the ultimate muscle fibres, for *increase* of excitability. Yet, according to Dr. Remak, we must always make a rigid distinction between the *excitability* of a nerve or muscle and its *capability;* for these two terms are not, in these connections, the same.

I have never as yet been able to discover any diminution of susceptibility from the moderate use of this method of using a current, as to strength, say twenty Daniell's elements, or half power of induction currents; and as to time of each alternating, say, for an average, every fifteen to thirty seconds; and as to length of *seance*, say five or ten to fifteen minutes, — so far as it was shown by pain and prickle, by contractions, and other sensations. Not only so, but there is usually an *increased* response to the manœuvres of the electrodes; for where a motor nerve is embraced in the current that did not at first show any muscle twitch, it will, after a very few turns of the current-changer, respond by strong contractions in its depending muscles, or in their antagonists. This proves M. Marianini's observation to be correct, that "the *induced opening contraction* always indicates an increased preparation for the response to the production of the opposite current." We also find that this increase of susceptibility is augmented all the more, the more *suddenly* that change in the current is produced.

"*The Tetanus of Ritter*" — so often quoted, but, after all, seen only in the *dead* frog — I believe has never been observed in living men; i. e., after employing the constant current for remedial purposes: nor is any moderate working of a current able to render either a nerve or muscle not susceptible to the entrance of the same or the opposite current. But still I believe this might be produced by an unwarrantable and abusive use of a very powerful and painful current, repeatedly applied and reversed by a metallic current-changer, if persisted in for some time. So is a *guano* island desolate; and when guano is too powerfully applied to a field or orchard, it is well known that it kills; but in that very *power*, when rationally employed, consists its undeniable fertilizing capabilities.

*Polar-working* of either the primary or secondary current is a term given to whatever effects are produced *at the site* of the two electrodes, at the entrance, during the stay, and at the leaving of the current. This term, therefore, covers those older terms of "convulsion pole," "painful pole," and also those changes which were produced, or rather were supposed might be produced, by a protracted application of the electrode in the same spot.

Grapengeisser, Matteucci, and Remak, particularly, state that the action of the zinc pole of the constant or *primary* current, as of Daniell's battery, is the strongest. We find that the down-running of such a current produces stronger twitching at the closure of the circuit, during the closure, and at the moment of taking it away; while the up-running current produces more twitchings and longer enduring contractions, both at the making and breaking of the current. This *rule* applies not only to the superficial nerves at the borders and surface of the muscles, — as this can be distinctly seen by trials on the muscle biceps, — but it applies also to the deeper ramification of the motor nerves, even those situated deep inside the body of the muscle.

*Intra-polar workings* of electric currents are those which become apparent, even in healthy persons, in the territory of the ultimate ramifications of a nerve that is being embraced in the electric current; as, for example, where the current has been applied and maintained in the contrary direction to the natural nerve-current; and thus a modification in the latter is produced.

*Extra-polar working* of a current is simply that which is produced outside of the direct route between the two electrodes, and which is manifested by sensations or motions not properly arising through the nerve fibrils embraced by the current. These effects are more easily traced in sentient than in motory nerves. Under this head we will call attention to the fact that any one can observe, viz., that when employing strong induction currents, as upon the nerves and muscles of the arm, if the electrodes are pressed hard upon or over the motor nerve, *it lessens the pain*, and at the same time causes the contractions to take place stronger and deeper. This is a strange phenomenon. It

has been thought by some, that the constant primary current, and also the secondary current, does not act by a true *central* reflex action, but rather by the *painful* excitation of the peripheric nerves, such as are pairing off with their fellows of motory nerves, and thus causing contractions by a kind of *local* reflex action. But if this be so, how can we explain the fact just mentioned as to the Faradaic phenomenon? According to this view, when lightly applied electrodes with strong induction currents cover the region of a nerve, then there should be more contraction, because more pain. But we see that by pressing the electrodes deep into the flesh, the pain is *less*, while the contraction is so much the greater. It cannot be an exclusive action, then, of that sort.

We find that good electro-muscular contractions are not always to be produced either through the employment of Faradaic or Galvanic currents even on the nerve trunk, or on a pure motory nerve, until its branches in the muscles themselves have reacquired their excitability by the action of the current, i. e., by the *extra-polar* working of the current, which is possible even on the motory nerves; but this is realized, probably, only under certain conditions of the peripheric extension workings produced by the current.

*Polar alternatives* are those alternating motions in the managing of the electrodes during a *seance*, that is simply the removal or disturbance of one electrode while the other remains, and then the removal of the latter while the former remains, and so on, either alternately, double alternately, or treble alternately; i. e., three times lifting the one, and then the other three times, &c. By such manœuvres we are enabled, by means of one and the same galvanic, or even electro-magnetic current, to expose two different muscle groups, or nerve groups, in an *unequal* labile excitement — a means of great value in a portion of cases that present for treatment. Those phenomena which appear in very excitable muscles, belong to the local workings of current variations in the nerves and muscles together, as where a current is directed through the motory nerve *peroneus*, which occasions, even at its leaving, a contraction in the depending muscles;

while a current of equal or greater strength, directed in precisely the same manner through the muscles themselves, shows no sign of contraction. If, now, we place one electrode on the muscle and the other electrode on the nerve trunk, then the lifting up of the *latter* electrode will produce contraction, while the lifting up of the other will leave the muscle still at rest; and this difference between the two will be the greater, the more care we take to produce waving or staggering of the current, just as the electrode is leaving the skin.

"*Alternations of Ritter*" may be understood by placing the two electrodes, say the one on the nerve *medianus*, and the other over the nerve *radialis*, in the neighborhood of the bend of the elbow where those nerves come nearest the skin, and then make contact from a battery of some thirty to fifty Daniell's elements, for there will appear, as a general thing, immediate contraction for flexion, which may also last while the current runs, producing a fair bending of the arm from the action of the flexors. Sometimes, however, this appears rather in the extensors. But if the direction of the same current is now reversed by means of the metallic key of the key-board, and that while the electrodes remain as they were upon the same spots, then the previous contraction, after a momentary recess occasioned by the turning of the current, appears again, (*and now with increased strength*,) or even will show it in the antagonizing muscle groups. Now, in case this latter result obtains, if the current direction be changed again very suddenly, as before, then the previous contraction comes in again, and this "alternation" appears so much the more readily in proportion to the suddenness and frequency of the changed directions of the current. Occasionally these results do not appear until after the changing has been repeated several times. Sometimes, moreover, these alternations of the current are attended with contraction of the flexors from the up-running current, while the down-running current produces contraction in the extensors; and this order of events follows the regular turnings of the current.

*Labile workings* of primary, and also of secondary elec-

tro-magnetic currents, can be most easily produced by *changing the position* of one or both the electrodes up or down on the nerve course, or over the muscle fibres, so as to increase and diminish alternately the distance, and hence the amount of substance and resistance there is *between* the poles. This, I find, often proves actively remedial, even where it does not cause any visible contractions.

*Labile contractions* are those which are produced in the muscles, or in the muscle nerves, simply by variations in the density of the electric current that passes through a given fibre, or group of fibres, or twig of nerve that ramifies the fibres, (but without actual interruption,) according to the *law* laid down by M. Dubois-Reymond, namely, that a muscle responds by contraction not only to the interruption of the current, but also to a variation of the current. These labile contractions can, therefore, be produced when, from the effects of the current, the nerves and muscles have acquired a certain degree of excitability, and if we then give to one or both electrodes the least move, or by gliding them along a little without actually removing either of them from the skin, the muscle fibres over which the moving electrode approaches go into contraction, while those other fibres of the same muscle, or other muscles that the electrode leaves, at the same time cease to contract. If, now, the button-like electrode, that is covered with wet cloth or wash-leather, be moved along in a wavy or undulating manner *over the course of the nerve*, then all the muscle fibres depending on that nerve will be affected; i. e., if they are in a state of sufficiently high excitability. Those fibres near by and immediately touched will also be influenced, but in a less degree. On the whole, the working will often *appear* to be the strongest in the muscle fibres themselves. We can produce analogous *labile* excitement in the nerve trunk that occasions tonic contractions of varied degrees, according to the resistance the given current meets in its way. Labile contractions can also be produced by directing one electrode so as to glide over the point of insertion of the tendon into the *farther end* of the fibres of the muscle.

We are led to notice that, for instance, in lean persons, when

the *platysma myoides* is caused to contract by Faradaic or Galvanic excitement, the skin of the neck is raised into sharp folds, over the contracted fibres of that muscle, from the *transversal* arrangement of the electrodes above the clavicle. Now, as soon as one of the electrodes is swept along, we get the labile contractions in the successive fibres over which it passes. But the contractions are still stronger if the electrodes are situated so as to be according to the anatomy of that muscle; i. e., longitudinal with its fibres, if the electrode movements regard that mainly, although obliquely. In such muscles as are attached fleshily to the bones of the joints, the mechanical effect of the current is almost nothing when the electrode passes transversely across the fibres of them. But we can increase this effect, as, for instance, on the extensor muscles of the relaxed and down-hanging hand, *by a proper position or support, as of the forearm*, so that the current will then simply, from that little aid, produce a full lifting of the hand to a horizontal posture, while the electrode moves along rather obliquely across the direction of those extensor muscle fibres on the forearm, and thereby changing even the *labile* contractions into a gradually increasing tonic together-drawing of the fibres of the extensor muscles, and thus producing a good stretch of the hand.

Sometimes we notice the labile contractions of the contractile tissues and muscle fibres will appear *only* at the moving, and not at all at the stationary electrode. This is according to the excitability of the contractile fibres that come respectively under the electrodes. If the trial is reversed, i. e., if the previously moving electrode is now held at rest, while the other one is caused to vary and move a little, then, even, will the very same fibres twitch which are under or near the electrode that is at rest. This can be tested in another way on a large scale, as with whole muscles or nerve groups, if we place one electrode, for instance, on any point of the upper or forearm we choose, as on the nerve *medianus*, while the other electrode is made to move over the nerve *radialis*, or its motory branches in their muscles. The flexors will at first remain at rest, while only the extensors will get into a state of labile movement; i. e., after a

time, when they have acquired a sufficient toning-up from the current stimulus, (which, however, sometimes fails to occur,) but which can be easily ascertained by a reverson of the trial. Even in cases of nerve and muscle sickness, and where the extensors are deprived of all voluntary capability, neither are able to be excited more by localized Faradaic currents directed to those muscles, still will their *labile* excitement, under the same conditions, bring about a contraction in the antagonizing flexor muscles, and this simply because the flexors were in that case already more susceptible to the influence than were the extensors.

Judging from all electro-therapeutic experience, we are led to conclude that the so-called constant or primary current of galvanism can place the nerves of a given case, even after an almost *stabile* in-working on them, in a condition most favorable for the exertion of the voluntary influences of the will; or, in other words, to convey the natural messages of volition; and this, in plain words, means *to reëstablish the lost capability for normal action*. This constitutes *the cure*. Furthermore, we find that, for instance, in one portion of the cases of atrophy, the wasted muscles can certainly be plumped and rendered more firm and warm by the occasional practice in them of *labile* contractions. But this increase in size is seen to be limited to those fibres or portions of the muscle which take on this response to the action of the current; from this it is quite apparent that the enlarging or growing of the mutscle fibre groups is produced by an actual absorption of liquids along the sides of the muscle fibres, whose endosmotic capability has been thus increased by this current, or method of using it. The same can be done, but with more difficulty, by means of well-managed electro-magnetic currents.

*By-workings of the current.* — Under this head, and with all due deference to the views of Dr. Duchenne, we should first state our profound conviction that it is impossible to be quite sure of ever *limiting* the effects of any Galvanic or Faradaic currents to a single nerve or muscle only. Rather is it apparent in practice, that in every case a more or less simultaneous excitement of both the sentient or skin-nerves, and of the motor or

muscle nerves, as well as of the neighboring contractile tissues also, is unavoidable; to say nothing of central reflex-action, which some of the most experienced and distinguished electro-physiologists and therapeutists also claim as a uniform result. The influence of the applied current, we find, will spread sometimes more, sometimes less on either side, as well as beyond, the straight line between the acting electrodes; and this seems to take place all the more through the adjacent and more moist tissues, the longer the current is kept in action at one spot. Where we are working a current over a nerve trunk, or the muscle, the only way almost that I have found to determine whether the stream is capable of gaining the proposed end, is to test whether the interruption of the current excites any contraction through the *motory* nerves. In many cases we find the evidence of good in-working through the *sensitive* nerves, by an eccentric sensation, which is a sign, whether *all the radiating fibrils* of the nerve are excited in an equal manner.

There are a very great number of by-workings of the primary current that are not so important. There is, however, an effect of this kind whenever an active current is applied about the head or neck, which causes flashes of light, dizziness, silver taste, or sound, besides a tendency to tilt the head over towards the removed electrode, for it is not during the steady working of the current that these results obtain, so much as at the putting on or taking off the electrodes. These effects are to be avoided, i. e., not to be often repeated with strength at once, as a mere experiment, but nevertheless are to be observed in practice as valuable *evidence of sufficiency of current for the given case*, and that the action of the current is certainly going on.

*By-working* of either primary or secondary currents on the heart is rarely produced; indeed, I can say that I have never as yet seen any kind of such effects, either in healthy or sick persons, from any of my ordinary rational applications, such as are required in treatments. But I would never risk the trial very powerfully, either for experiment or for treatment.

There are not unfrequently kinds of *after-workings* of this current in well persons, and in sick persons also, which should

be mentioned. In one case, perhaps, several hours after the *seance*, there will be sensations in the joints very similar to those produced at the time, by the in-working of the current; in another patient, there will be the silver taste often repeated; in another, there will be sensations like those from the vibrations of induced or secondary currents; in others, a prickling in a distant part or limb, which, perhaps, shows itself repeatedly; or there is a glow, or even a perspiration, where the skin has before been peculiar for its dryness. In other rare cases there are even automatic movements of particular muscles, or groups of muscles, that are repeated from time to time. Now, whenever any of these phenomena occur, we can rest assured that, whether the patient is benefited by our treatments or not, the needed degree of profound electro-nervous excitability is certainly not wanting.

Messieurs Becquerel, Dubois-Reymond, and Remak, are severally of the opinion that the properly managed primary constant current of galvanism can produce good and effective service in spasmodic diseases, not because of the paralyzing effects, nor from that tendency, but, says the latter, "because in certain cases *it restores to the central organs their power of dominion over the actions of the nerves and muscles*, the want of which produces or *allows* clonic spasms and cramps; in other cases, because it removes, by electrolytic in-workings, the peripheric or central irritation, where such is possible, through which many cases of spasmodic conditions are produced, and maintained, often, until the organism is self-destroyed."

In some eminently practical observations, Dr. Remak further says that, on account of the great variations in the excitement of the motory and sensitive nerves of patients paralyzed from *central*, or even local peripheric causes, it is absolutely necessary for the physician who proposes to apply the *primary* current of galvanism, as a remedy, to be first well equipped with every facility necessary to give him *a perfect command over the current* as to strength, the varying of its intensity, interruptions, reversing its direction, and as to electrodes of different sizes and material, as also the simultaneous and similar command of an ample induction or Faradaic current. He needs these, he says,

at least, to work up the sunken excitability of the nerves, so as to produce powerful contractions, and, at the same time, not to torment the sensitive nerves, nor yet to fatigue or exhaust the muscles. He mentions that he has found the current-changer of the key-board of great use in clearing away the tonic contractions of paralysis, and of old rheumatisms. He says such contractions are not relieved by an exclusive excitement of the once antagonizing muscles now paralyzed, nor of the muscle nerves. He then urges, in this connection, how little use is the mere local excitement of the muscles, and the nerve branches that are among the muscle fibres, in all those cases where the excitement of the larger nerve trunks is in effect, at least for the time, utterly lost. On the other hand, he shows the real curative effects of localized Faradaic treatments in those cases where the excitability of the large nerves is truly *diminished*, but not entirely gone as in lead palsies, for here we find the excitability of the branches in the muscles quite gone. Even in some cases of "progressive muscular atrophy" he found the excitability of the nerve trunks less than the ultimate twigs that were in the muscles, although then far wasted by the progressive palsy. He here recommends, therefore, first of all, and in every case, to ascertain and define, for one's own mind, the exact amount of excitability of the nerve trunk, and then proceed to the restoration, now in this, and then in the central direction, as we may find indicated, or to give the best results.

The degree and extent of the true electro-muscle excitement, according to the results of comparing trials, appear to be *in proportion to the sum of the motory nerve branches or fibrils that are embraced by the current* — i. e., that lie under, near to, and between, the electrodes. Dr. Remak interprets the weak or partial surface-workings of the electric current, from being applied along the course of the muscle fibres, as only the consequence of an excitement of the few superficial nerve twigs embraced, and which he terms "*extra-muscular action;*" while the deeper total muscle-workings of the current, which are produced when directed into the muscle by its largest nerve trunk, he terms "*intra-muscular action.*" Dr. Duchenne terms the former, as we

have shown, *immediate*, or "*direct, Faradaization;*" and the latter, *mediate*, or "*indirect*, Faradaization," for, as we have also said, Duchenne believes in the Hallerian irritability. Remak believes that nerves are absolutely essential to muscular contraction.

Without giving details, I will say that it has been fairly demonstrated that the blood vessels, including both the arteries and the veins, of the thigh of a living animal, as of a frog or rabbit, which has been subjected to the immediate action of a very "*strong* current of induction" for some ten minutes, do then actually dilate.

Drs. Duchenne and Remak have both of them Faradaized the diaphragm of man, the former operating through the *phrenic* nerve. The latter says, "The diaphragm seems to be a participator in the acts of respiration even more than any other of the thoracic muscles, and is susceptible to immediate electric excitements. I have produced by Faradaic currents, on some healthy young men, instantaneous, violent, and painless contractions of the diaphragm, which were indicated by the vaulting of the abdominal parietes on placing one electrode 'in the pit of the stomach,' while the other was on the most prominent curvature of the seventh and eighth ribs on the right side. It was interesting to observe the phenomenon while the currents were retained there, for, immediately after the current was applied, the tonic contraction (which was inferred from the arching of the abdomen) ceased, even while the current was still running. This was then gradually succeeded by a to-and-fro flapping of the parietes of the abdomen, and at the same time these persons expressed a conscious feeling of hickup. This clearly proved that the diaphragm was assuming its natural rythmatic contractions, even in the midst of the action of the electric currents, and while struggling with them. When the electrodes were removed, the diaphragm took on its normal functions."

The rule is then obtained, that in order to electrize the muscles truly, methodically, and at the same time beneficially, either by Faradaic or Galvanic currents, we must become familiar with the bifurcation of the nerves, which is synonymous with the

"*border points*" that simply mark the entrance places of the large nerves into the muscles. This knowledge is most readily obtained from experience in practice, and from trials on healthy persons; or on very recent subjects, as can be done only in hospitals or almshouses. Since the motor nerves almost invariably enter the muscle on its sides, we will, in doubtful cases, or if but little experienced, or in such as where the immediate affection of the nerve is, on the whole, not probable, act more judiciously by moving the metal *ball electrode*, covered with wet wash-leather, along the borders of the muscle, back and forth, until the spot is found and manifested by a good contraction, than by simply resting large sponge electrodes any where over the muscles, and regarding only the muscle fibres, according to the method of Dr. Duchenne.

The operator, although inexperienced in all this, will soon discover that he can produce a together-drawing, or contraction, of the muscle *biceps*, for instance, or of the muscle *deltoides*, or of the muscle *pectoralis major*, far easier by applying the one *small* and *wet* electrode to the spot of nerve entrance, and with the other so situated as to direct the electric stream lengthwise and somewhat obliquely across the muscle, than if he seeks to act only with reference to the long direction of the fibres of the muscle. I need hardly remark that in cases where the revival of paralyzed muscles is sought for, we then more especially must choose those points for the site or nucleus of wavy movements for one electrode, which, by trials on healthy persons or on the very recent subject, are shown to produce the most prompt and powerful effects. By this method, then, we succeed more surely, use less current, accomplish more in less time, and occasion less pain; and in the more doubtful cases of apoplectic paralysis, we also avoid any great degree of hazardous excitement of sensitive nerves, which will yet be more generally acknowledged to produce a uniformly greater or less degree of reflex action.

We have learned from Sir Charles Bell, as well as from our own trials, that the muscles do not distinguish between the sensation of heat and cold; and, besides, every surgeon is familiar with the fact how little pain the muscles experience when being

cut through; yet it may be possible to produce pain in muscles by means of the electric excitement. Dr. Duchenne observed that the electrization of raw muscle surface in a wounded fleshy patient produced only a dull kind of sensation, but no actual pain. I have already spoken of the manner in which large muscles can be brought into a painless, active contraction; and these form no exceptions, but are rather the daily experience in my practice.

Dr. Romburg, in his learned and excellent work on Nerves and their Diseases, distinguishes two great classes of conditions of the sensitive nerves of muscles — the one *hyperæsthetic*, the other *anæsthetic*. The normal shortening of the muscles during movements of the members takes place, it is true, without causing much, if any, sensation. But we learn further, from M. Weber's researches, what part the muscles take in the sense of *feeling* of tension, as when carrying burdens, as also in the pains we feel during cramps in the calf of the leg, during inflammations of the muscles, &c.* Now, this is a difficult question to solve, whether in all these cases the sensation experienced proceeds from the abnormal state of the muscle fibres themselves, or from their surroundings of sheathing tissues. According to the researches of Dr. Remak, the tendinous prolongations of the thin, flat muscles, as of the diaphragm, the *latissimus dorsi*, of the eye muscles, and others, present to ocular demonstration numerous nerves of medium size, composed of such fibres as led him to believe that they are none other than nerves of sensation. I have frequently demonstrated on healthy young men, who were my students, the possibility of managing the electrodes, even with a moderate current, so as to bring the *depressor anguli oris* to a tetanic contraction without causing the least feeling, as they themselves stated.

A man presented for treatment, or rather for advice as to the expediency of the electric treatment, whom I found to be afflicted with true apoplectic paralysis involving the *portio dura*. When testing the nerves and muscles of the face very gently,

* Ludwig's Physiology, vol. i. p. 360.

we found a small branch of the nerve *supra orbicularis* to run within a very trifling distance of the *border point* of the muscle *frontalis;* that is, from the entrance-spot of the motory nerve into that muscle. The two points are not half an inch apart; yet when one is touched by the electrode it occasions pain; when the other is touched there is a complete contraction of the whole muscle. The other muscles of the face are very similarly related, and for good reasons. It is thus that we discover, even on the smallest muscles, this pleasing result: that the currents of Galvanism, or of Faradaism, whose application insures the most powerful effects through the motory nerves — which are manifested by contractions — are also often the very ones that are productive of the least sensation or pain.

The operator, after all, cannot entirely avoid the sentient nerves. It would, therefore, be really desirable to have some means of uniformly avoiding or alleviating this annoyance and real drawback in electric treatments. Dr. Duchenne recommends the bringing of the two electrodes together before applying them to the skin. This is well to be remembered. We may (as is my own method) also apply the electrodes first, and then introduce the soft iron within the helix very gradually, while using Faradaic currents; or if Galvanic currents, begin with the switch on a low key, or no key, and then by running up the scale until the number of batteries is indicated by the produced prickling sensation, or by the galvanometer.

### *Methods for using the Faradaic Currents.*

*To electrify the Nerves.* — As regards the importance of a carefully, definitely directed transmission of the electric current — whether it be frictional, voltaic, galvanic, or faradaic — along the course of the nerve-trunks, *in a certain given direction*, especially in certain classes of cases, we must insist that we have very decided reasons — which are deduced from the study of the chapter on electro-physiology, and are confirmed by practice — for adopting, practising, and teaching it. For this reason, and to aid others to improve in practice, that chapter is intro-

duced. In fact, these are the very fundamental ideas that pervade this whole work. Not only the kind of current, and current *direction*, but also current *interruption*, *reversion*, and *duration*, we hold, are of the highest importance.

By placing the two electrodes over the course of a nerve, the positive being the farthest from the head, with a space of an inch or two, more or less, between them, of course there is an up-running current. It would be the same if the positive electrode was being moved over the depending muscle, or even if situated any where, provided it be below or beyond the site of the negative. When a current is so directed, it most keenly arouses the nerve towards its centre, and the centre also, and thus arouses the whole nervous system. Very many cases of nervous and chronic affections will not admit of this procedure; therefore, in these, it must be carefully avoided.

By the same disposition of the electrodes, if the poles are changed so that the positive is now where the negative was in the previous statement, we know there is now a down-running current, that is, from the centre outwards, towards the depending muscles. If such a directed current, moderate in strength, *be steadily run*, that is, without the least wavering or interruption, for five, ten, or fifteen minutes, it has a calming, soothing effect on most irritable and painful nerves and muscles.

By the same respective position of the electrodes, if now the current *is suddenly reversed*, as by the current-changer of the apparatus, or if even sudden interruptions be made, as by the foot-board, or by repeatedly touching the inner tip of the conductor to the button of the apparatus, there is produced a most thorough stimulating effect of the nerve and its depending muscles, as also at its centre. Then, if this procedure is combined either with a mainly up-running current or down-running current, we regulate the stimulating effect in any or all directions as we wish. But if the current is run only transversely, *across* a nerve or muscle, it has only a little and uncertain effect. These views we conceive to be fundamental.

Nevertheless, the large practical experience and learning of Dr. Duchenne, of Paris, lead him, it appears, to the following

somewhat different conclusions, which are condensed, but not altogether indorsed, by the author: —

1. "In man, whatever may be the direction of the currents, or the degree of vitality of the nerves they traverse, the same results are always produced when the conductors are applied to any portion over the course of the nerves — namely, muscular contractions and sensations.

2. "When a moderate or pretty strong current is prolonged for a considerable time, running along a healthy nerve, whether the current be continuous or intermitted, i. e., primary or secondary, if there are intermissions, it weakens neither the sensations, the contractions, nor the voluntary movements; nor produces any reflex phenomena above the point excited.

3. "Where an electric current is long protracted in its running through a nerve that is already considerably debilitated, it very notably lessens its excitability, but without influencing the voluntary motions in the depending muscles.

4. "Various changes in the current-direction produce no appreciable influence over the sensibility, or capability of voluntary muscular contractility, in man.

5. "Electrization of the terminal nerves, in a limb, produces sensations only in the points thus excited.

6. "An electric current which is caused to pass from the nervous terminals towards, or to, the nervous centres, acts principally on the sensibility of the limb, and produces above the point thus excited contractions which are irregular, and not in proportion to the degree of sensation."

Thus Dr. Duchenne regulates his treatments accordingly, in all, or nearly all, nervous affections, regardless of the relative positions of the electrodes, or the direction of the current, while operating; for his method being mainly *one*, — "*localized faradaization*," — the necessity for observing current-direction is somewhat obviated. He thus entirely ignores the fundamental laws of Dubois-Reymond, with a single exception, viz., "Should there be cerebral lesion existing at the time, the *inverse* current might do serious mischief." (Duchenne, p. 97.) He ignores the fact that headache and neuralgia may be produced by a strong

up-running current, even when there is no brain lesion. He ignores the fact that the sudden and repeatedly reversed current, while over the course of a nerve, is capable of working up tonus, muscle contractility, hyperæsthesia, and even irritability; and that the steady down-running current, coursing through a nerve-trunk, or nerve and muscle, or through the whole limb, produces, in certain other cases, a calming and permanently strengthening effect.

Such being the views of Dr. Duchenne, we can readily see why he so generally directs, in all cases, the grand electric remedy as a simple "*localized faradaization.*"

Localized faradaization is performed, first, by employing some kind of faradaic apparatus, either galvano-magneto-electric, or magneto-electric. Then, holding the two small brass-tipped electrodes in the same hand, so that they are but a very little separated, they are applied to the skin, dry or wet, according as we may wish to affect sentient or motor nerves, and thus holding them on, or moving them over, the part desired to be faradaized. For this purpose the *wire-brush* may be used as one pole, or electrode, it being most effective.

The effect of this kind of procedure is said to be "localized," that is, confined to the spot operated upon, or as limited to the skin. Second, the two electrodes may be covered, at their tips, with wash-leather or sponges moistened with water, and applied, as before, near together, over the moist skin, situated over the delinquent muscle. For faradaizing, the electrodes must never be more than from one to four or five inches apart, using a very smart or intense current, which produces little or much pain, that must be borne while this is being performed. We should aim to bring the whole of the muscle-fibres successively *in some oblique direction between the electrodes*, as also embracing the supplying nerve-branch, when possible, and so gently moving one electrode, or both, so as to electrify the whole. This, for some classes of cases, to be described in treatment, is most valuable. Hence I do not wish to be understood as disapproving of localized faradaization. I, on the contrary, for certain cases, greatly admire and practise it. But what I do object to, is the

subjecting of all cases suitable for electric treatment to this one method of application, and ignoring the existence, the approachableness and influence of nerve-trunks, and the polarity of the nerve-molecule.

*To electrify the Organ of general Sensation — the Skin.* — For this, conical *metallic* electrodes may be used, with full power of faradaic electricity, or thirty to fifty cups of galvanic electricity. If too painful, in the given case, use less current, else *dry the skin* by means of flesh powder or flour. Faradaic electricity is usually employed for this purpose, — using a high power of intensity, — as best adapted to allay local morbid hyperæsthesia, or pain, and for producing *revulsive* and *reflex* action. It may also be accomplished by drawing numerous short sparks *from* the skin, by the negative arm of a friction machine; as also by the succession of quick taps of electric heat from a button-faced metallic electrode, heated by a constant current of galvanism. This is my most valued revulsive and local alterative.

But, perhaps, the most powerful local nervous stimulant for the skin is the *wire-brush* electrode, attached to the negative pole of a highly intense faradaic current. To a healthy part of the skin, that is, physiologically, this performance can be rendered perfectly atrocious; but when there is anæsthesia, it is not readily felt. But it will arouse sensation and pain in any given part that is at the time possibly susceptible of it, or where it may possibly be ultimately induced. In all these cases the metallic brush, the ball, blunt or pointed metallic electrodes should be applied *near together;* or else one over a nerve-trunk while the other is on the affected part, and so moved, gliding along, over the surface of the skin, more or less, continuously, during the seance, usually so as to be not more than a few inches apart; or one may be planted stationary over the site of pain or palsy, (anæsthesia,) while the other is slowly or quickly glided about it. This I term *single circle movement.* When the two electrodes are moved thus back and forth about each other, in part circles, simultaneously, I designate it as the *double circle movement* of the electrodes. When they are applied to a given spot, and retained there, I speak of the application as *stable*, or *stabile.*

*To electrify the Muscles.* — For this we proceed in one of these methods: either we must seek to operate entirely through the supplying nerve, by there applying both electrodes, with the positive nearest the head; or through the nerve and muscle together, by applying the positive electrode over the nerve-trunk, and the negative over the muscle; or else applying both electrodes directly on or over the muscles themselves, (by reflex action?) The skin should be moist, and wet sponge electrodes are best for this purpose. Where a deep and powerful effect is to be produced, as over a nerve, we often use the metallic ball electrodes, which work still better if covered with wash-leather and are well moistened with water. But my *spoon-shaped* sponge and rubber electrodes are the most convenient and the easiest to the patient, and are, therefore, most generally employed, especially when the patient suffers from a smarting or stinging effect on the skin.

When a healthy muscle, or group of muscles, is electrified according to my method, with a due galvanic or faradaic current, using my spoon-shaped electrodes, the muscle or muscles are seen to be brought into full play entirely without pain; but when performed by the method of Dr. Duchenne, the surface pain is decidedly sharp, and the muscle contractions are at the same time attended with a pain more or less considerable and peculiar, which is quite distinct from the surface or skin pain, and is referred to the belly of the muscle. I am enabled thus to accomplish the same work, *usually without* any sort of pain, that his method and apparatus perform *usually with considerable pain.* Not only is this my own judgment and experience, but it is the testimony of very intelligent patients, who, having received these treatments in Paris, by *faradaization*, for certain nervous affections, for the same affections had the same muscles electrified in Boston until a cure was confirmed.

*First.* I am careful to employ no more battery power, nor helix power, than just sufficient to produce the full and easy electro-muscular contractions in the given case.

*Second.* We use large, moist, fine sponge electrodes, spoon-shaped, of some one and a half by two inches in diameter, of

level and soft surface. The sponges in these electrodes — of which I keep some fifty pairs always in readiness, for I never use a sponge electrode on a second patient without cleansing it — are choice bits of the finest texture and smoothest surface sponges the market affords, and are to be kept scrupulously clean.

*Third.* We seek to guide the positive electrode mostly over the nearest superficial nerve that supplies the muscle or muscle-group that is to be electrified; while at the same time the negative electrode is made to glide back and forth slowly and *obliquely* over the whole length and breadth of the given muscle surface; or else, or next, moving them simultaneously. We are sometimes to alternate them, if the case will permit, by single circle, double circle, or differential movements; or else to completely change their relative position, from time to time, say every ten or fifteen seconds, or half minute. Thus, by some or several of these manœuvres, we are enabled to thoroughly electrify deep-lying muscles, and even sick muscles with irritable nerves, with comparatively little disagreeable sensation; and also in such cases as cold, chronic rheumatism, paralysis, and simple nerve and muscle debility, not only without producing pain, but with a most agreeable sense of muscular motions that are sensible to, and appreciated by, these patients, who often express regret on having the *seance* close, and rejoice to have it repeated.

The electrodes are never to be allowed to rest long upon bony spots or tendons, with an active current, (excepting when purposely adjusted over joints,) for they are thus apt to produce pain, or a soreness, or an aching, that may be lasting; besides, it is doubtful if, in such places, where the current is so resisted, the electricity can do any good. Ignorant persons suppose, and have often been told, I learn, that there is disease in such places, because of this effect of the electrodes. Finally, for the smaller muscles, and for reaching more accurately the nerve-trunks, and for other more exact work, very small sponge-tipped electrodes, with a slim shank insulated, as may be seen on page 390, should be chosen, and will give more excellent results. I consider a

suitable electrode, for a given operation, of very great importance.

But where there exists a painful or hyperæsthetic state of the nervous system, perhaps symptomatic of some diseased condition of the great nerve-centres, all these manœuvres by reversions of the electrodes, as also the up-running of the current, are totally interdicted. All such cases must be touched by the current only with the utmost caution and precision. In some cases the sensibility to pain is so readily produced or increased that this mode of stimulating the muscles cannot be repeated. Where such a state is suspected, we must only employ a very moderate current, and that always steadily, in a down-running direction, through large, moist, fine sponge electrodes.

Aside from hyperæsthesia and neuralgia, there are cases, perhaps from diseased or damaged nerves, where the muscles appear still to retain even some voluntary power, yet show no procurable electro-muscular contractility; while, at the same time, the electric sensibility is so great that no sort of current can be tolerated for a moment. Such cases, however, are rare exceptions to the general rule. Blisters are usually here first indicated, and then the electricity.

*To electrify the Ear.*—I do not approve of Dr. Duchenne's method of filling the ear with water, and then introducing into it the end of the wire conductor, as he directs. My method is first to moisten the meatus and tympanic membrane thoroughly with warm water, or soap suds, by means of a long camel's-hair brush; then to introduce the ivory ear electrode with a tiny sponge-tip moistened, until it is near to or against the drum of the ear. The operator should be seated behind the patient, the latter reclining in the operating chair, with his head steadied in the head-rest, or on a cushion. Adjust one large sponge electrode, positive, at the back of the neck, back of the ear, or over the opposite ear, or else the small electrode at the eustachian tube, according as the case may seem to require. Then take the wire end of the other conductor, negative, in the operator's hand, (using a very small current,) and so lightly touch the protruding wire of the already adjusted ear electrode with the

tip of the finger of the same hand that holds the conductor, so as not to injure the patient at first. Then, by degrees, the current can be gradually increased, or the finger moistened to make the contact more sure and complete. The ear electrode should be as deeply inserted as the patient well can bear.

Indeed, in my own practice, I can judge much of the sensibility of a given case simply by the introduction of the ear electrode, and thus, as it were, sounding the ear. Then, if quite insensible, I apply the wire of the conductor directly to the fine wire of the electrode, without the intervention of the hand; thus increasing or diminishing the current, or reversing it, as the case may seem to demand. We may proceed thus gently for five or ten minutes, and find that patients will bear faradaic or galvanic electricity, strong enough to accomplish all that is possible to be done, by this means. It must not be too painful; if it produces a noise, or a sensation on the tongue, or a metallic sour taste, it is quite strong enough. Thus used, in all proper cases, it is a perfectly safe treatment.

*To electrify the Organ of Smell.* — Any insulated shank, with a small metallic tip, or sponge tip, for an *electrode*, may be passed over the sniderian membrane with the primary or secondary electricity. If it is for loss of smell, or to rally from impending death, the faradaic current is best; as also in other cases, providing any considerable amount can be borne; if not, then resort to galvanism, with the positive large sponge electrode situated on the nose, under the chin, or at the pit of the stomach, and make smart, quick work of it, for what is to be done here should be done quickly.

*To electrify the Organ of Taste.* — An insulated stem, with a moderately small metallic end, or a sponge-tipped electrode, faradaic, and negative, may be passed over the surface and sides of the tongue and the palate, while the larger sponge electrode, positive, is placed at the back of the neck, under the chin, or at the pit of the stomach. If the current-direction is reversed, so as to run from the tongue, positive, to the back of the neck, negative, the effects on the great nerve-centre will be much greater; and if primary galvanism be employed, instead of the

faradaic current, then the central effect will be still very much greater.

*To electrify the Organ of Sight.* — For a muscular rheumatic, atonic, or a neuralgic or painful affection of the eyes, or *about* the eye, the faradaic current is almost always to be preferred. But for stimulating the optic nerve, friction electricity, as negative sparks, may be *drawn from* the eyeball through the closed eyelid; or primary galvanism may be passed from the positive sponge electrode at the *nuche* to the negative sponge electrode, that is being gently moved over the closed eye, and about it, as if bathing the eye with electricity; or one sponge electrode may be placed on each eye, and changed every few seconds. If flashes of light, or a metallic taste, is produced, the strength of current is quite sufficient.

*To electrify the Base of the Brain*, the medulla oblongata, and the great nervous centre generally, we must apply an *up-running* current, directed towards the head, from along the spine; that is, apply the negative electrode at the base of the occiput, while the positive is planted at the coccyx; or is being moved slowly along up and down the back, or else held at some given point along the back, and every few seconds interrupted. Thus, by a current directed upwards, the medulla and brain are aroused and stimulated. By the same manœuvres with a *down-running* current, the great nerve-centres are also electrified, in a more moderate degree, but with a calming and down-toning effect, provided the current is moderate, steady in strength and direction, long continued, and not varied by being removed and re-applied at the same seance.

For effecting this most profoundly, the primary current, as from ten, twenty, or thirty Daniell's cups, is the most efficient. The next is the extra current, as produced by modern faradaic apparatus. If these are not at hand, the faradaic current, that is, the magneto-electric, or galvano-magneto-electric, may be employed. The application should be from one, three, five to fifteen minutes at a time, and repeated every other day, or twice a week.

While these are my regular methods, yet the same effect may

be produced by variations of this principle, for we cannot affect any one point of the brain without affecting the whole in some degree. Therefore, when desirable, as for a lady in dress, for instance, one electrode may be adjusted back of the ear, on one side, while the other is at the sternum, or on the shoulder, or just down the back a little. But be careful as to the current-direction.

*To electrify the Throat.* — For a rheumatic or debilitated state of the pharynx or larynx, and especially for palsy of the cordæ vocales, when not depending upon, nor complicated with, any organic disease, or lesion, nor symptomatic of other disease, electricity is the most valuable of all known remedies.

A small, slim, curved, *insulated* electrode, with a metallic tip; or sponge tip, is to be gently passed along down the pharynx, below the posterior part of the larynx, while the other, a larger sponge electrode, negative, is applied over the crico-thyroid muscle, on the outside of the throat. Then the current is to be let on, and the inner electrode is to be pressed forward against the larynx, and then moved gently up and down for a quarter of a minute or so at a time. Some throats will tolerate this procedure, but in others I have failed to succeed. Yet it is one of the most direct methods for electrifying the throat nerves and muscles, as for a weak or rough voice, or total loss of voice — *aphonia.*

The voice is sometimes restored, in certain patients, by simply faradaizing, *smartly*, the skin over the outside of the throat. This is also a most excellent procedure for the diminished strength, and roughness of the voice, sometimes affecting those who speak or sing much in public, or in the open air; which may thus be relieved, and the voice restored.

*To electrify the Vital Organs.* — The heart, stomach, lungs, and liver are not only reached through reflex action, produced by the electrodes being placed on, or moved over, the given organ, but all these organs are *directly* acted on by primary or secondary electricity, through the pneumo-gastric nerve. By applying the pharyngeal electrode in the upper and lateral parts of the pharynx, and the sponge, positive, electrode to the nape

of the neck, all these viscera will be under the direct electric influence. But if we make the application to the lower portion of the œsophagus, which is done by a long, flexible, insulated electrode, with sponge or metallic tip, passed down the throat gently until near the cardiac orifice, then placing the other electrode, a large sponge, at the pit of the stomach, the electric influence will reach mainly the stomach and liver. The current should be moderate, and employed in short applications; or rather with frequent intermissions, between the applications, during the seance.

This is a delicate procedure, and requires care. If too strongly applied, it will produce faintness, and a sensation of suffocation. I usually finish each such seance by gliding the sponge electrodes as *hazing* (gliding them about each other lively) with smart faradaic currents over all the vital organs; that is, about the thorax, front and back, and around the waist. This often prevents spasm or cramp.

*To electrify the Abdomen and its Contents, including the Uterus, the Ovaries, and the Bladder.* For this we must employ some kind of apparatus that is active; for here, in most cases, is required considerable power. Large sponge electrodes are also best adapted for this purpose. One, positive, is to be adjusted first on the back of the neck, while the other is applied about the umbilicus. Then increase the power of the current gradually until the patient feels it very decidedly, or we see electro-muscle contractions. Thus we can bathe over the abdomen with a flood of electricity, as also over the region of the liver or duodenum, the colon, spleen, stomach, and diaphragm, the bladder, or the thorax, as absolutely as we formerly could with a liniment. This may be continued for five or ten minutes.

One, the negative, should next be placed at the umbilicus, while with the other electrode bathe about it very slowly, but smartly, over the whole abdomen, or over any given region of it, for another five minutes. Then *haze* the electrodes, or move them in double-circle motions. Now, if our object is to tone and contract the bladder, the positive electrode should next be applied at rest under the coccyx; but if for the relief of pains

in any of these parts, (excepting for ileus, constipation, stoppage, or flatus, with *atony*,) it should be adjusted rather down the thigh, at the inside of the knee joint, while with the positive bathe the abdomen, or the painful spot; or else arrange and adjust it in the rectum, vagina, or urethra, as the case may be. For obstinate constipation, for flatus, ileus, or intussusception from atony, the negative electrode must be carried well within the rectum. For more minute directions for electrifying the uterus, &c., see Rule 10, p. 466.

*To electrify the Male Genitals.* — One electrode may be introduced into the rectum, while the other, negative, is passed down the urethra to the stricture, or the prostate gland, or *vesiculæ seminales*, as the case may be; or one electrode may be planted at the coccyx, while the other is guided over the perinæum, or through the urethra into the bladder. All but the metallic tip of the urethral electrode must be thoroughly insulated, for otherwise the sensation from the electricity, near the meatus, would be most horribly intense, while the current would scarcely reach the deeper parts at all. See the cuts of such instruments in chapter of apparatus and electrodes.

Where there is any lurking inflammation that is any way active, or any malignant disease in these parts, all forms of electricity are not only useless, but are contra-indicated; while for incontinence of urine from debility, impotency, *loss of power of erection*, or loss of power to eject the semen, or in atony and insensibility of these organs generally, the electric influence should be directed along the whole course of the urethra, by gently gliding the urethral electrode down and up the passage repeatedly, with all the current — primary, extra, or secondary — that can be tolerated for five or ten minutes. Then finish each seance by gliding the sponge electrode, negative, which has now replaced the urethral, over the lower bowels, and along the dorsum penis, over the perinæum, and about the loins and inner sides of the thighs, while the positive sponge electrode is all the while at the coccyx, or is arranged to be in the rectum. A very smart current needs to be employed for these sittings.

*To electrify the Rectum.* — For paralysis of the rectum, or

sphincter ani, for incontinence of the fæces, for rectal constipation, or atony of rectum, and for prolapsus of the fundament, where the sphincters are debilitated or paralyzed, the electrodes are to be directed to the sphincter muscles inside and out. The insulated metallic-tip rectal or vaginal electrode should be gently moved up and down the passage just within the anus from one to four or five inches, while the positive sponge electrode is planted at the coccyx, or is moved about over the perinæum, the electric current being as strong as the patient can bear. The rectum is, physiologically, but slightly sensitive to the current, to within about half an inch of the outside; but the skin surface of the anus, close about the passage, is, on the contrary, exceedingly sensitive to the current. This must be borne in mind, so that sometimes we shall find it convenient to make the inner electrode negative, and then carry the positive first to the coccyx, then to the lumbar region, and then over the lower abdomen, so avoiding that tender region about the anus in some of the more sensitive cases. For electrifying the uterus, see Chapter IX.

*To cauterize the Rectum*, by galvanic heat, as for hydatids, and other purposes, see chapter on Surgery.

Where the smaller branches of sentient nerves cannot always be avoided, and as the fine plush of skin nerves is every where present to greet the electrode, I usually employ a *strong pressure of the electrodes on the skin, to lessen the skin sensation* and pain; and this proves a most effectual means, as can be tested on the forearm or on the *interossei* muscles. Patients usually assure me that they do not feel any thing really disagreeable; and yet perhaps the muscles are in full play from the influence of the current. Others say that the sharp prickling or burning sensation produced by the too light or careless application of the moist ball electrode ceases as soon as it is more firmly held; and then in its stead there comes a dull, but more supportable, deep-seated, indescribable sensation. It is necessary at the same time not to make the pressure too great, for this will increase the pain rather than diminish it, not only from the pressure itself, but by conveying the current to the *periosteum* of some underlying bone. It is also important and necessary ever to give the

parts we wish to operate upon a firm and easy resting posture, such as will also make the *border point* of the muscles accessible, where it is possible to be done. Nor must we be too ready to remove or incessantly slide the electrode this way or that on the skin, unless it is to avoid a painful sentient nerve, or to move to, or more surely fix upon the exact spot we have been led to believe is the most suitable. The better way is to choose the spot, and then apply that electrode boldly and firmly at once, and hold it with a steady hand from second to second, or minute to minute, or less, but never more. These directions apply, however, more especially to the treatment of paralysis.

My advice is to commence with throwing aside the awkward yet every where provided and used metallic electrodes or "handles," as they are called. The custom has been to hold these in the hands, or to stuff wet sponges in their outer ends, and thus apply them to the body, or else drop one of them into a bath tub, together with the feet or hands. But all this is unphilosophical, hap-hazard, and, in plain words, sheer empiricism. It is better to make use of fixed insulating electrodes provided with metallic oval ends or surfaces, that vary both in form and size. Of these, some should be covered with large and very fine sponges; others with very small; while others should be covered with thick wash-leather; each must be thoroughly wet or moist (as well as scrupulously clean) when used. The moisture employed may be water or salt water. In my own practice I use pure water exclusively for the last moistening of the electrode sponge or leather.

I employ in anæsthetic and paralytic cases three sizes of metallic oval-shaped electrodes: the first is half an inch in diameter; the next is one inch; the next is two inches. For the *interossei* and other narrow places, I have others wedge-shaped, so that they can be easily crowded down between the phalanges; and these are very useful, also, where the nerve trunk lies deep, and we wish to bury the current-giver deep into the thick flesh. Such electrodes are preferable for cases of paralysis, and wherever there is nerve or muscle anæsthesia. But for almost all kinds of hyperæsthetic cases of nerve, joint, or muscle affection, then the broad, soft and moist sponge electrodes are rather to be

chosen. Success in this practice greatly depends upon these nice points. Mr. Thomas Hall, the electrical instrument maker of this city, has made for me, and other physicians and surgeons, a great variety of very handy and useful electrode instruments of this sort. (See Chapter IV.) Thus I have endeavored to give here the *general principles* and some of the *minutiæ* to be observed in managing the *electric sitting* of a patient. (See p. 460.)

### *Faradaization.*

Dr. Duchenne, of Bologne, is unquestionably entitled to the honor of having first of all introduced into medical practice the excitement of single muscles, or muscle groups by electric currents. The precepts, however, which are contained in his large work on the method of application of "localized electricity" appear far from being sufficient, either in number or explicitness. Dr. Duchenne, we observe, distinguishes two classes of operations; first, the *mediate* electrization of the muscles, through their nerve trunks; second, an *immediate* electrization, i. e., applying the electrodes directly to the single muscle, or bundle of muscles. The electrodes are in every case to be placed as near to each other as possible, while each of the two classes of electrizations requires otherwise different management. The technical terms he employs on page 47, to designate his particular method are, *direct muscular Faradaization, and indirect muscular Faradaization,* — which consist in causing every muscle or bundle of muscles to contract singly, by placing the moist electrodes, or *excitors*, as he terms them, on those points of the skin "which correspond with the surface of the muscle to be Faradaized." Nothing, he says, is easier than this way of Faradaizing, especially on the surface regions of the body and limbs, when the operator is acquainted with certain anatomical facts; but that it is more difficult with respect to the deeper layers of muscles, although almost all of them can be reached at certain places by direct excitement. The excitors should always be placed on the fleshy part of the muscles, but never on the sinews or tendons of the muscles. To Faradaize a muscle

completely, it is necessary to embrace the whole surface of it by the excitors. The current must be strong in proportion to the thickness of the muscle.

This term originated with Dr. Duchenne; and I now proceed to give an account of his "*method*" of using *induction currents*, as explained in his large and popular work, *De l'Electrisation localisée, et de son Application à la Physiologie, la Pathologie, et la Therapeutique*, Paris, 1855. He first states, "that if the skin and the metallic electrodes are both perfectly dry, then the currents of induction do not penetrate into the subjacent tissues, but reunite on the surface of the epidermis; and that in this case there are produced *sparks*, (!) with a special crepitation, but no physiological effects." Now, we must mark this statement of his, for evidently he is employing a machine for producing induction currents, such as we never think of employing in this country for medical purposes. His method and rules will not therefore always apply to us, nor shall we be liable to meet with his mishaps, nor yet, perhaps, with his marvellous cures.

It may, therefore, be laid down as a rule, first of all, that *the* electricity which requires a given rule and regulation for its employment, as also those physiological and remedial results that are brought about by any prescribed method of use, are *determined, in part at least, by the kind and efficiency of apparatus used to provide the given electricity.* This proposition may be transposed thus: A correct *rule* for using one kind of electricity does not always necessarily apply for the use of another electricity, whether it relates to the kind as static or dynamic — to intensity or quantity — to Galvanic or to Faradaic electricity — to constant, inconstant, or alternated currents; nor will there follow the same safety or danger, failure or success. With our eye on the *kind* and *power* of current employed by Dr. Duchenne, we will proceed to pass in review his leading propositions and *modus operandi*.

When dry excitors are applied to the skin that is also dry, he says, there is produced a sensation of heat or burning only; but

if the skin is likewise thick, then there is no kind of sensation. If, then, the electrodes are wet, or the skin is wet, neither spark, nor crepitation, nor sensation of heat is produced; but a phenomenon according to the position of the electrodes. If they are planted over the body of a muscle, then there is a contraction of that muscle, or at least of the superficial portion of it, together with a sensation that is not peculiar to the skin, but that always more or less accompanies the electro-muscular contraction. He defines this sensation as being like that produced by acting on a muscle that, for example, has been laid bare by a wound, so as to be no longer covered by the skin.

Again, if the electrodes are positioned over the course of a mixed nerve, then contractions of all the muscles animated by this nerve are produced. Hence the proposition for his two grand different methods of proceeding: first, by applying the electrodes directly to the body of the muscle; second, by applying them rather to the nerve trunk that animates those muscles. The first method he designates as "*direct muscular Faradaization*," the second method as "*indirect muscular Faradaization*." In both cases he directs that the electrodes and the skin should be wet. For this purpose he employs mostly large wet sponges, which are in part stuffed into the ends of hollow metallic cylinders, or handles, which are insulated on wood. But for limiting the electric force to and in a muscle of a smaller size, such as the *lumbricales*, *interossei*, or muscles of the face, he employs "small conical electrodes," which he more frequently terms "*excitors*," but which are simply *poles*, or *electrodes*.

But it was left for Dr. Remak, of Berlin,* to point out, and for Dr. Ziemssen to demonstrate, clinically and anatomically, those defined spots, which are found to correspond with the points of entrance of the motor nerves into the lateral borders or *edges of the muscles*.† The latter marked upon the skin of the patient, with nitrate of silver, such lines and spots as proved electro-muscular responsive,— to the there placed electrode,—

* Uber methodische Elektrisirung gelahmter Muskelen, Berlin, 1856.

† Die Electricitat in der Medicine, Berlin, 1857.

and then, after death, by dissecting the motor nerve branches to their entrance into the bundles of muscle fibres, he thus found that these two series of experiments agreed with each other perfectly, in every respect. Hence Remak and Ziemssen are both of the opinion that there is no muscular contraction by exactly direct localized electrization of the muscles, as Dr. Duchenne claims, but contend, on the contrary, that in every case the contraction is brought about by the interposition or coöperation of the muscle nerve.

The trunk of the *facial* (*portio dura*) *nerve* can be reached from the external opening of the ear, or after the nerve emerges from the stylo-mastoid foramen just under the ear, by placing one electrode between the *mastoid process* and the *condyloid process* of the lower jaw. But he thinks neither of these ways should be resorted to in cases of paralysis of the portio dura, because from that point in the ear the feebler currents produce no effects on the muscles of the face; while if we employ requisite currents to produce an effect on the face muscles, the electric stimulus is then inevitably conveyed to the superficial *temporal*, or to the *auriculo-temporal nerve* from the third branch of the *trigeminal* (*tri-facial* or fifth) nerve; whereby a very annoying pain is also produced. He, for that reason, advises seeking the nerves that branch from the *portio dura*, where they emerge from the parotid gland; or else limit the position of the electrodes to the individual muscles that are affected. He says he finds a slight difference in the exact situation of some of these face motor nerves, in some persons, but that the electrodes will soon discover them.

In the *supra-clavicular* region, the electrodes, if placed directly over the collar bone, act on the *brachial plexus*. If placed on the summit of the *supra-clavicular* triangle, they are then over the external branch of the *spinal accessory nerve* of Willis. The *phrenic nerve* is reached on the anterior surface of the *scalenius anticus*.

Dr. Duchenne also maintains that both nerves and muscles possess very different degrees of *excitability;* and for that reason

it is necessary to adjust the strength of the current *to the given excitability* of the nerve and muscle to be treated. He also mentions a difference of *muscular* sensation in different muscles while contracting. This he termed "*muscular consciousness.*"

To *Faradaize* the *skin* he recommends *three* principal processes. The first is by the "*electric hand;*" i. e., of the operator. The patient takes one electrode in the hand, and holds it during the *seance*, while the physician holds the other electrode in his leisure hand. After having dried the skin with flesh powder, the operator passes the back of his hand over the surface to be excited. A lively crepitation is the only phenomenon produced, except, perhaps, over the forehead and face, where it becomes painful. It is the advice of the author, whenever this is done, that the operator use the same hand that holds the electrode, so as to prevent the passage of so high an induction current through his own person, which is thus to himself highly injurious and unsafe to be so long continued, or often repeated.

The *second* process is by means of solid or "smooth metallic excitors," which are adjusted to insulating handles. The skin is to be dried as before; but if the epidermis is very thick or hard, as on the palms of the hands, then the skin may rather be a little moist. When it is necessary to produce a strong effect on a certain point, the excitors are held for a given time lightly in contact with the skin. These solid metallic excitors, he says, are often insufficient for the palms of the hands and soles of the feet, whatever intensity of current may be used. In such cases a bit of wet wash-leather over the face of the brass electrode will render it at once effective.

The *third* process of Dr. Duchenne is by means of the *metallic wires*, or "brush electrode"—a bundle of fine wires adjustable in the hollow end of the common electrode. The skin is quickly and more or less lightly tapped or beaten with the ends of this wire brush, while held perpendicularly to the surface of the skin. But sometimes it is necessary to retain them longer in contact with the skin, as in cases of palsy of sensation. Indeed, Dr. Duchenne recommends this for many cases of anæsthesia, neuralgia, and muscular rheumatism.

To *Faradaize* the internal ear, he advises one electrode to be on the back of the neck, and filling the ear tube with warm water, then introducing into the water thus filling the external ear, the wire tip of the primary or secondary conductor of an induction machine, and maintaining it in the midst of the water, while the current flows, but without touching the sides of the ear passage if possible, nor yet the membrane of the tympanum. But this is so difficult to be done, so disagreeable to the patient, and so ineffectual, that the author has instituted an entirely different method, by employing an *ear electrode* of ivory, sponge, and silver wire to convey the galvanic current, or the faradaic current, in this treatment for noises and deafness, which is more practical, agreeable, and more frequently successful. (See p. 262.)

For *Faradaizing* in partial amaurosis, loss of taste, and premature diminution of sight, he advises "the employment rather of the continuous galvanic current, because it exercises a very much more remarkable influence on these organs than can be produced by the induction currents of electro-magnetism." But how does Dr. Duchenne (and other writers who seem to take all his propositions without question) reconcile such facts, declared by himself? This is no declaration of another — no *ex parte* testimony. A late English writer testifies that he has found the best effects from the use of moderate *galvanic currents in affections of the special senses;* and yet, in the same work, he cautions against the employment of these same currents on the large nerves and muscles of the limbs, for fear of the effects reaching the brain! I cannot account for this opinion, if given from experience in practice, unless, as in the former case, — i. e., when using *galvanic* electricity about the face, — care was taken to use the smaller intensity, also the occasional, or, perhaps, more frequent interruptions of the current, as it certainly should be only so employed; while in the latter case a stronger inverse current was allowed to traverse a nerve trunk, or group of muscles, persistently for some indefinite time, which would almost necessarily do injury rather than good. To apply any considerable current of galvanism to the nerve

trunks, muscles, back, or head of a patient, and retain it there for some time, regardless of the condition of *variation, of density* of current, or of interruption, direction, or alternation, &c., would be a foolhardy and highly hazardous experiment. In my opinion no such current should ever traverse the part more than one minute at a time, at the longest, although repeated again and again in the same place and manner. (See p. 465.)

The *Faradaizing* of the *diaphragm* for quickly producing artificial respiration is, according to Duchenne, best done by applying the one electrode over the *phrenic nerve*, which takes its rise from the third, fourth, and fifth cervical pairs, and is to be reached on the anterior edge of the *scalenus anticus*, and just at the back edge of the middle of the *sterno-cleido-mastoideus* muscle, while the other electrode is placed at the pit of the stomach, with a down-running current. Let the electrodes be wet sponges with large surface. The *instant* they are applied, the artificial respiration is usually produced; the thorax heaves, and the air rushes forcibly into the lungs; thus by applying and removing one electrode as often as this phenomenon is repeated, it is possible to keep up a respiratory process for a time, even after death. *Perseverance* must be the motto here; for in all cases of apparent death from water, strangulation, lightning, asphyxia, from chloroform, opium, carbonic acid gas, &c., to establish and maintain respiration, *is* often found *to save life.*

The *Faradaization* of the *larynx* is done by means of the small olive-shaped instrument, which is passed down (without the current) as far as the posterior and inferior portion of the larynx, while the other excitor, as in the previous cases, is then placed on the nape of the neck; or it is better sometimes to be situated outside, front of the throat, on a level with the *crycothyroid* muscle. Thus situated, they may receive the current gently at first, and at the same time the sponge is moved about a little. But he says the *indirect* method is easier, and often effectual. One excitor is in that case placed over the *inferior constrictor* muscle on the anterior portion of the throat, and so reaches the *inferior laryngeal nerve.*

### *Electro-puncture.*

*Electro-puncture* is the sub-cutaneous application of the different forms of electricity. Thus acu-puncture needles become sub-cutaneous electrodes. One, two, or more needles inserted into the flesh may connect the circuit of a friction machine, either directly from the prime conductor, as an influence or aura, or through the Leyden-jars, as a mild or full shock; or they may connect with the poles of the galvanic battery; or with a faradaic machine, according as the indications of the given case may require.

Acu-puncture, simply of itself, is believed by many physicians of learning and experience to be nothing less than actual electro-puncture, though no primary or secondary current be brought to bear upon the inserted needles. That is, the needles passing through the skin and tissues to parts deep beneath, act, they say, as *conductors* for the insulated electro-nerve or chemical current, which has become morbid, and thus modifying the local action, and restoring the equilibrium in the given spasm or painful spot.

Electro-puncture needles are to be considered, then, as a peculiar sort of sub-cutaneous electrodes. Their employment, with a gentle current, is the ancient "*acu-puncturation*" intensified in results, without being made a tithe more painful. Not one needle in ten need be in the least painful. Patients uniformly bear it well. The result for *non* inflammatory pains, if not malignant or organic, is as promising as tooth extraction is for inflammation, while it is nowhere near so painful. The speedy relief, and the valuable cures thus sometimes made in long-standing and troublesome cases, are enhanced a hundred fold by this dexterous little process. Such, in fact, have been the results of my own experience.

In the hospitals of St. Louis, La Piété, and Hôtel Dieu, of Paris, I saw this operation of acu-puncture performed in a variety of ways, and for a variety of maladies; where, also, I was informed that it had been practised some thousands of times, and in every case without the occurrence of any unpleasant effect

beyond occasional faintness or pain — it generally occasioning only the sensation of a little shock or prick, or a slight smarting. The rule was to avoid active inflammations, and the coast was considered clear for this kind of treatment. Among the many distinguished advocates of this procedure is J. Cloquet, who has done and seen much of this practice, and he approves of it, decidedly, when judiciously performed. Even the puncture of nerves, he says, does no harm; the pain is generally but trifling, and speedily passes away. But should the puncture be attended with any considerable pain or smarting, the needle may be withdrawn, and reinserted in another spot. Indeed, whenever the insertion of the needle proves to be very difficult or painful, my own method is, to immediately withdraw it, and as quickly insert it again in some contiguous spot where it will pass easily, and with little or no sensation, excepting, perhaps, a prick or shock; for if the needles enter readily, that is, quickly, with little or no pain, and without much force, we may all the more surely calculate for a degree of success.

Numerous experiments and accidents show, also, that no inconvenience follows the purposed or accidental puncture of arteries or veins by fine needles. A few drops of blood, perhaps, may issue; but this is rare, and may be readily stopped by pressure for a few seconds with the finger. If there is slight ecchymosis, it soon disappears. However, the nerve-trunks and blood-vessels, tendons, fascia, and the periosteum of bones, are to be avoided in these operations. If there appears a halo of a red color, about the site of the needle, it will be without tumefaction, and will soon disappear. If a soft iron or steel needle is employed, it is somewhat more painful at the insertion, and considerably more so at the extraction, than unoxidizable needles; nevertheless, I should employ such in emergency. What good comes from sub-cutaneous injections may yet be proved to be, mainly, the combined action of an opiate with the electric or alterative action of the acu-puncture, produced by the point of the syringe.

*Methods.* — First, the insertion of the needle or needles for acu-puncture, electro-puncture, or galvano-puncture, may be

skilfully performed by simply *stretching*, or else pinching up a fold of the skin with the thumb and fore-finger of the left hand, and dexterously passing in the needle, without hesitation, close to the thumb pressure, and in an oblique direction. When once through the skin, it can be pressed forwards in any direction more deliberately. My experience leads me to say that it proves to be, so far, less painful to patients than anticipated; that they often exclaim, "Why, that is nothing; no more than a prick of a pin!" The effect on the economy is electric; some patients experiencing a sensation of shock to the whole body, but which may be neither painful nor very disagreeable. More frequently, however, the shock is only experienced in the parts about the puncture. In other, more numerous, cases, there is only a tremulous sensation, and a tremulous motion of muscle or muscle-fibres, that is visible as well as sensible. Sometimes there is a thrill along down the limb, or even to distant sensitive parts. Frequently, when inserting these needles in the cervical region, as for occipital neuralgia, or for torticollis, when the affection was complicated with sciatica or hysteria, the patient experienced more sensation in the arm, hand, hip, or knee, than at the point of penetration. So soon as the vibrations in the muscle cease, or in case no such effect is produced, we may proceed at once to introduce the chosen current, through the needles, into the deep parts beneath. But one needle may be required in some cases, a sponge electrode answering for the other. Only a very small electric current is to be employed.

The needles for these purposes should be from two to four inches in length, of an unoxidizable metal, *very fine* and sound, well polished, insulated, and sharp pointed. The point should be lance or slim spear shaped, so as to cut its way with the least pain and little required force.

Platinized, untempered, or soft-tempered steel needles, with a small knob or ring at the eye end, are preferable for all cases except for coagulating blood, as for varicose veins or aneurism. Such needles I obtained in Paris at one dollar each by the dozen. These I have had fire japanned, excepting the head-ring and some half inch at the point. This perfect insulation prevents the

electricity from leaving the needle at the surface, and so delivers it all from the point where directed. I have also employed gold needles, and *gilded, soft-tempered steel needles.*

But when such cannot be conveniently obtained, long, *fine*, steel sewing needles may be selected, and heated to redness, and then allowed to cool slowly in the air, so as to lose their brittleness, and be made safe. To test this, spring them well, and see if they are tough and reliable. Then polish them in emery cushions, and head them with sealing-wax, so that they shall never be lost in the flesh. Such needles do very well, provided they are not left in the tissues of the body more than ten or fifteen minutes at a time.

A handle with a steel socket, called *porte-aiguille*, or needle-holder, a convenient article for holding and inserting these needles, is manufactured by Drs. Codman & Shurtleff, the makers of elegant surgical and dental instruments, 13 Tremont Street, Boston. They can also furnish the best of acu-puncture needles, either of platinum, gold, zinc, iron, or steel, and suitable electric apparatus, with instructions.

As a general rule, the seat of pain, the rheumatic deposit, dropsical effusion, or palsy, &c., will indicate the place where the needle should be planted; but sometimes the knowledge of anatomy and physiology alone must guide us. The number of the needles to be inserted at once is left to the judgment of the operator; they may be from one or two to a dozen. Generally, the smaller numbers are all that a case requires. The frequency or repetition may be as soon or seldom as the urgency or abeyance of the given case demands. My method is never to leave a needle inserted longer than ten or fifteen minutes, in all, at any one *seance*. When the operation is well performed, the relief speedily experienced is remarkable and durable.

When employing static electricity through these sub-cutaneous electrodes, it is better to commence by *influence*, that is, with a continuous flow of electricity without noise or spark; or else by *drawing* sparks *from* the needle inserted; and when the discharge is changed from the negative end of the machine to the prime conductor, so as to *give* sparks of greater length and

strength, begin carefully with short and light sparks, and pass but few in number, say five, or a dozen, or more, and watch the effect.

When employing the primary current, as galvano-puncture, it is best not to use great intensity. From one, two, five, to ten elements are all that should be so employed, (except in cases of blood coagulation, as for varicose veins and aneurisms.) The coarse wires that lead from the battery to the helix in the faradaic machine may be removed, and the conductors put in their stead, so as to lead the *mild-quantity* current directly to and through the inserted needles, by simply touching the heads of them with the wire tips of the conductors. If several galvanic cups are in the circuit, or if the nerve is weak and sensitive, deep muscle-fibre contractions are readily produced. For blood coagulation we must use three of Grove's, ten of Smee's, twenty or thirty of Daniell's, or, what is better, the *extra current*, quarter strength, of the *Petit* medical battery, as manufactured by T. Hall, 15 Bromfield Street, Boston. The extra current of this battery will electro-plate, and do much work of the true primary galvanism, as well as yield the most powerful current of electro-magnetism. It is the most powerful little battery found in this country, and equals the celebrated Ruhmkorff's coil, that is run with the bisulphate of mercury. (See p. 374.)

When employing the faradaic current, or the extra current of the faradaic machine through acu-puncture needles, it is best to begin with the smallest degree of strength, and so increase until visible muscle contraction or pain is produced. The wire of one of the conductors from the apparatus, at least, should never be fastened to the head of the needle, but adjusted in the operator's hand so as to make or break the current instantly. Indeed, often, as in palsies, and wherever increased nerve-action is sought for, this interruption and reversion of the current are very necessary. And it is obviously necessary in cases of sudden pain or cramp, as tonus will sometimes set in quickly, and when least expected. When this occurs while using any form of electro-puncture, by a suspension of the current for a few

seconds, or if aided by pressure, it will cease; and it then may be repeated with good effect.

The primary current through needles (galvano-puncture) from one, two, five, to ten cups of Daniell's battery, has in my hands given the most speedy and satisfactory results. But this is available only at an office. The next best is the *extra current* from a faradaic machine; and if this is not available, employ the common faradaic current, of a weak and bearable strength. My methods thus enable me to recommend an almost painless procedure, both as relates to the insertion and the current. Hence I would lay great stress on fine, long, excellent needles, dexterous insertion, and small currents of electricity skilfully manipulated.

It cannot now be questioned that electro-puncture does exert such an alterative or chemical power by electrolysis and catalysis over morbid nerve-action, morbid muscles, and morbid deposits, as to materially modify the nervous action, the circulation, depuration, and nutrition, in those parts to which it is applied. Magendi regards electro-puncture as the remedy *par excellence* for obstinate neuralgia, old rheumatism, incomplete amaurosis, and other local, long-standing palsy. Sarlandiere employed electro-puncture for the above affections when uncomplicated with organic mischief or inflammation; and where such does exist, he advises that antiphlogistic local or general remedies should be premised.

In a paper recently read before the French Academy of Sciences by Dr. Shuster, of Germany, it is contended, indeed, that electricity is principally useful, as a remedy, only when it is introduced into the substance of the affected organ by means of electro-puncture. As such, he says, this remedy constitutes one of the most powerful and harmless agents we possess. He related complete success by this means in *varicose veins*, for dropsies, both *anasarcous* and *encysted*, and for *hydrocele*, *ascites*, (idiopathic and symptomatic,) for serous and synovial *cysts*, for *goitre* and *aneurisms*, for *chronic* gout, neuralgia, and rheumatism, for *partial* and *periodic* amaurosis, and especially for *palsy of the retina*, for *aphonia*, *nervous deafness*, &c.

*Electro-Chemical Bath.*

Sir Humphry Davy observed, as long ago as in 1807, that if he immersed his fingers in a glass vessel filled with distilled water, connected with the *negative* pole of a galvanic battery, alkalies were excreted from his body and deposited in the pure water; but if the positive pole was in contact with the water and fingers, then phosphoric, sulphuric, and hydrochloric acids were deposited, and could be detected in the distilled water.

Electro-chemical baths, known as "Dr. Vergenn's," and which figured in all the country for a while, were but the hasty result of an IDEA, put forth to the world by M. Poey, who relates the origin, treatments, and consequences. It seems that in 1852, a man occupied with electro-silver plating in the city of New York, having had his hands in a solution of the nitrate and cyanure of gold and silver, a severe ulcer was produced, which proved very obstinate of cure under the most active remedies. At last the patient plunged his hand into the electro-chemical bath, at the positive pole, that was being employed at the time for silver plating. After holding it there for a quarter of an hour, it was found that the metal plate connected with the negative pole was covered with a thin layer of gold and silver. Then, by a few more such applications, repeated day after day, the electro-chemical bath proved sufficient for the cure of the ulcer. Upon that hint was based an idea which soon grew into an hypothesis of great magnitude.

Dr. Poey, of some southern city, soon prepared a paper on the subject, which, in 1855, was laid before the French Academy in Paris, in which he asserted "*that it is possible to extract metallic substances out of the human body by the aid of electricity*,— whether such poisons had been taken as remedies, or had been lodged in the body by absorption from exposure in some of the different arts and trades."

The electro-chemical bath is administered as follows: The patient is placed sitting upon a bench of wood, which is fixed low in a deep and large metallic bath tub; all of which is in-

sulated from the ground. The tub is then filled with warmish water until the patient is up to the neck in it. If it is supposed that the patient is poisoned with mercury, or with silver, or gold, then the water is acidulated with nitric or hydrochloric acid; but if lead is to be extracted, then sulphuric acid is added to the water bath, in the place of the other acid. The galvanic electricity must be large, both as to quantity and intensity, and the long-continued, even current is the kind for this purpose. The negative pole is connected with the foot of the bath tub by a binding screw, while the positive electrode is placed in the hands of the patient. The positive electrode is made of iron, and covered with wet wash-leather or cloth, to diminish the calorific action of the large-sized series of batteries necessary to run it. M. Poey goes on to give a graphic description of the mode of its action. He says the current circulates through the patient from head to foot, thus traversing all the internal organs, not excepting the bones, taking along with it every particle of metal which may exist in the organism; then, by restoring the metal to its primitive form, and depositing it over the whole surface of the sides of the bath tub from the neck to the feet, but always more abundantly over against that part of the body where the metal is supposed to exist. As an instance of this, M. Poey affirms that he once saw from a patient who complained of pain in the arm, in consequence of having taken mercury, the exact size and shape of the arm depicted or electrotyped upon the side of the bath nearest that arm, from the deposit of the metallic molecules which came out of the limb. He also affirmed that he had drawn from the femur and from the tibia of a patient a large quantity of mercury, which, according to some physicians, had actually existed in these bones for fifteen years!

But to deny that the electro-chemical bath is devoid of all effects on the human body, aside from the alleged extraction of metals, is but folly; yet at the same time there are the strongest reasons for doubting its utility or safety, as it has been thus far tested. More than one instance has come under our own observation of the injurious consequences attending this unphilosophical use of such galvanic power.

*Flesh-mellowing and Deep-shampooing* are the best terms I can find to concisely express my peculiar method of *handling the flesh*, which I have found so valuable an aid in certain classes of patients. By these terms I do not mean simply moving the skin, as the scalp upon the cranium, nor a superficial gliding of the skin over the muscles, back and forth; nor do I refer to skin friction, as by crash towel or flesh brush; nor is it a simple chafing, or "*rubbing*," with the hands. These have their appropriate place and usefulness; but they are to be avoided in other certain cases as much as possible, because they stimulate the sensitive skin-nerves, and would here produce hyperæsthesia; while my real object just here is to reach the vessels, the muscles, nerves, and deep fasciæ about the bones, *without* chafing or exciting the surface.

*Flesh-mellowing* and deep-shampooing are performed by simply grasping in each moist hand a whole handful of skin and muscle, and thus squeezing and working them as one would in working putty or mellowing an apple; or one hand being applied to each side of the limb, or each side of the shoulder, or spine, for instance, and at the same time *see-sawing* them alternately, but simultaneously. That is, while gliding one handful upward, the other handful is as quickly and strongly jerked downward, in such a manner as to effectually move all the muscles and flesh even down to the bones. These manœuvres, in my estimation, are a most natural and effective ally to electrical treatment for certain classes of cases we have to treat. Our whole duty is not done, in certain cases, when this is neglected. It may be performed before, during, or after the *seance;* or at home by some *strong*, warm-handed nurse, friend, or servant. A very good time is just before retiring for the night. But it is hard work, and requires more strength than persons are often called to exercise, if continued for a quarter or half an hour *with a will*, as well as with the hands.

Flesh-mellowing and deep-shampooing not only aid electrical treatment in a given class of cases, but are a most efficient treatment by themselves in cases of tender and over-fatigued, feeble, flaccid, and trembling muscles, for atrophied or rheumatic

muscles, for asthenic palsy, and for contractions, provided the given case is not complicated with active spinal disease. I would not even except organic contractions in wasting muscles, if the damaged nerve has been already healed. These proceedings, together with electricity, are very valuable for coldness, either from injury or disease of nerve, or from want of blood circulation; in spasmo-paralysis, and for cold feet.

*Shampooing*, as ordinarily done, and *rubbing*, are of the greatest service as aids in the treatment of some cases; but, we repeat, it is not what is referred to here. To violently rub the part, as a barber rubs the head, will not do. According to Webster, *shampooing* is a Hindoo word, which means "*to rub and percuss* the whole body, and at the same time to flex and extend the limbs, and crack the joints, in connection with the hot bath." My method of flesh-mellowing, on the contrary, is rather a squeezing of the muscles, a gliding and a wringing of them around the bone, as thoroughly and as long as the patient can well bear. This is to be combined, or alternated, with certain electrical treatments for a certain class of affections.

That is, in suitable cases, we profoundly electrify the relaxed or sick muscles by a *hazing movement* of the wet-sponge electrodes; and in cases of contractions we direct the electricity mainly to the powerless antagonizing muscles and their nerve. Then, during the process, quickly dropping the electrodes, and placing the hands respectively on each side of the thorax, spine, or limb, as the case may be, and without chafing the surface, we repeatedly grasp handfuls of flesh for squeezing, and cause it to glide over the underlying bones in various directions for some minutes; then apply the electricity again, and so on, beginning rather gently at first, and then more roughly and thoroughly as we proceed, until there is a glow, and the patient feels comfortable and refreshed; but *never* so as to bruise the flesh.

The muscles are thus all exercised as well as the nerves; the blood in the capillaries of the muscles and fasciæ, all that is between the surface and the bone, gets thoroughly disturbed, squeezed out, and replaced by a fresh supply of blood nutriment. And the best single method for thoroughly arousing the

blood, nerve, and muscle inertia, is to mellow the flesh as a boy would mellow a lemon or an apple. Manipulate the flesh by grasping motions of the whole hand, as if it were dough or putty. Imitate the process of milking, only move the hands along a little each grip, and so compress and glide muscle upon muscle, and muscle and fascia upon bone, until all is aglow. Large and strong hands are required to do this well. No harder work, we say, can be found than this flesh-mellowing and deep-shampooing. It should be repeated several times with each sitting for electricity. I employ strong persons with large, warm hands for this purpose.

*Grand Dry-cupping.* — This is another most valuable aid to electric treatment, by coöperating in profoundly affecting the spinal cord, and the roots of the nerves, as they come out from it; as also for joints and muscles. It is a new method, and cannot be appreciated unless I here describe it. True, it is but a dry-cupping process, simply on a grander scale; but, in effect, it is adapted and intended to produce a far more thorough and deep disturbance of the vessels, nerves, and underlying tissues than any ordinary cupping, wet or dry. Cupping, we know, affects directly, and mainly, the skin and superficial capillaries. In this grander process, through means of large-surface vacuum glasses, we are enabled to draw into the enclosed skin-surface a pound or two, more or less, of blood and fluids with the flesh; while under all this, deep down beneath the base of the great vacuum, the parts are exhausted, blanched; and thus are held powerfully compressed for a given time, which may represent extreme ebb-tide. Then, as the valve is opened, the glass is removed and the surface is rubbed, the blood rushes away, and washes away, and allows new fluids to return to parts where all had lain stagnant and sick for a long time before; and this may represent a flood-tide. Rushing the blood this way and that, through a part, is an active alterative process.

It is to be performed during the *seance*. Apply first the electricity, and then the *grand cupping*, with or without the *mellowing and deep shampooing*, for a few minutes each, and so alternately for several times; but, of course, only in certain

appropriate cases. These vacuum or exhausting glasses are altogether unlike those in ordinary use for cupping, both in *size* and *shape*. I had them first made to order, at the glass-house, with plump, smooth, and variously curved rims, so as to fit easily over uneven surfaces; for instance, over given points and hollows along the very differently shaped backs; for the neck, over joints, and the limbs; or over the bones of the sacrum; over the shoulder-blade, between the shoulders, or over the ribs. Large glasses with rims to fit on a level surface will not do. It requires quite a number, each of different shape or size, to make a good set. Some two dozen are as few as this work can be done with. I find I am using twice that number. The following figures will illustrate some of the *oval* and *oblong* shapes: —

Fig. 110.

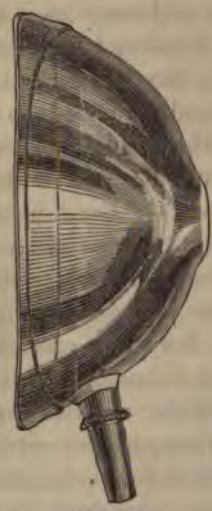


Fig. 111.

Fig. 112.

For applying over the loins of fleshy persons, over the sciatic exit, the stomach region, and the abdomen, I use a large, round, dome-shaped glass, that fits on a level surface, some six inches in every diameter — a quart cupping-glass. Others of this shape are five, four, or three inches in diameter. But the most of the set are *oblong* glasses, some six inches in length by three

in width; some more, others less, than this. Others have concave rims; others are oval, or oblique, so as to fit a twisted surface. One glass must be adapted to fit the deep groove of the back, as found in some persons, while others must fit over the poor or prominent backbones of other patients without hurting them; another is for the extreme hollow of some backs, or the bend of the side; for the crural exit, the cervical ganglia, or over the liver, or heart, or upper thorax, or base of occiput.

The exhauster is simply a noiseless india-rubber egg-shaped bag, that is worked by one hand, and obtains a good graduated exhaustion. The tube that contains the valve, and for attaching the glass to the elastic tube and egg, which latter has another valve at its outer opening, *is on the side*, as shown in the figures on the opposite page, and not on the top, so as to be conveniently managed under partial or loose clothing when desired.

Thus we can apply these vacuum glasses to the back, or any portion of the body, without undressing the patient. A man has only to undo the suspenders, unbutton the vest and waistband, and so pass it under the shirt, while sitting with his back to the operator on an ottoman. A lady need only unloose her clothing a little, without removing an article, when either the electrodes or the vacuum glass can be applied efficiently along any portion of her spine. True, it is easier to have freer access, and to see well the process. I only show thus what can be done, and well done. For this reason, too, I employ mostly my spoon-shaped electrodes, they do so facilitate the operations over the body and limbs, without so much uncovering the person — especially females. One can thus operate about the hip, the knee, or ankle, without having the limb entirely in sight. For I hold that it is as much the sacred duty of a physician to spare the moral sense, particularly of certain patients, or where there is in the given case any such sense to spare, as it is to spare pain or any other suffering.

Thus have I endeavored to delineate, in plain language, not only the outline, but even much of the *minutiæ* of my precautions and "*methods*" for the successful treatment of nervous chronic diseases. To render this more distinct for the young

practitioner, the following *rules* are also given; and to make the whole question of "*the medical and surgical uses of electricity*" more generally practical, the balance of this work will be devoted exclusively to practice.

Young medical gentlemen cannot be too early nor too deeply indoctrinated with the truth, that the uniformly successful practice of medicine depends as much upon the judgment and patience that carefully *executes the minutiæ*, or insists that the minutiæ shall be carried out, — it, the whole of it, and nothing but it, — as well as upon the grander and broader intellect and judgment that shall detect the disease, direct the plan of treatment, or choose the remedy. I trust that this humble effort may, in some degree, enable very many others to be more and more useful, and happy in a growing confidence in the esteem of an intelligent and highly-cultivated people. To be up with the age, and to afford to our confiding friends and patrons all that our science and art can yield, is but a duty; and when too old for active practice, this shall be one of our grandest earthly consolations — to be remembered in the hearts of the community as the good and faithful physician.

## NOTES TO CHAPTER V.

A. *Directions for the Electric Sitting, or Seance.* — These explanatory notes are introduced here to facilitate others, less experienced, in the employment of electricity, by making very plain some of the *minutiæ* of the author's *method*, (in sitting the patient, in managing the electrodes, and guiding the current, as *by a law*,) during each of the different *orders* of sittings instituted by him for the different classes of diseases appropriately so treated, and for such found most uniformly successful. The *systematic rules* here laid down for employing electricity as a remedy, although not found elsewhere in this or in any other language, are not the mere idea of a theory, but are the apparently well-corroborated results of the author's own clinical experience. The word "*seance*" means the same as if we should say, "a sitting for electric treatment." In my office — since this has been and is with me *a special practice* — we have four different orders of attitudes for the "*seance*," (as it is termed by the French,) and for these we employ, —

1. The *insulated* chair and stool.
2. The cushioned *ottoman*, covered with rubber cloth.
3. The *invalid's chair*, with a head-rest.
4. The *lounge*, with pillows, &c.

To prepare a person on the first *order* of sittings, the clothes need to be tucked up from the floor, &c., so as to *insulate* the patient as perfectly as possible.

To prepare for the second *order*, the object is, *to get free access to the whole back, thorax, and abdomen.* If the patient is a boy or man, let him merely unbutton his clothes, and thus take his seat upon the ottoman, stool, or a chair turned sidewise, with his back towards the operator, his shirt and under flannel pulled up above the waistbands; while the latter takes his seat on a low stool behind the patient, with his table of apparatus close by, at his right hand. In this arrangement he can freely manœuvre the electrodes, up or down the whole back, side muscles, thorax, abdomen, loins, hips, &c. If the patient be a female, let her lift or gather up the back part of her skirts, as she is about to take the seat; the corsets and dress are to be loosened, and thus the hand of the operator can be passed freely up the back, or from the neck downwards; so also over the sides, chest, muscles, abdomen, and loins, as the case may require, — *without removing the clothing.* In this attitude we also have easy access for adjusting one of the electrodes under the nates, coccyx, Poupart's ligament, or on the lumbar region, while operating on the nerves and muscles of the thighs and lower limbs with the other electrode.

The *reclining chair*, or rocking chair, receives the patient for the third order, and is used for all operations about the face, eyes, ears, head, throat, &c.

The *lounge*, or sofa, or cot, is the fourth order, and is desirable for a variety

of cases, such as where there is a contracted hip joint; so also for some affections of back, rectum, bladder, uterus, &c.

A. NOTE 2. A very small quantity current, such as that produced by the Humboldt battery, may be maintained *continuously* during the night, or even for days, with happy effects. So also the compound primary current of a Pulvermacher's may be applied for 5, 10, 15, 30, or 40 minutes at a time, and even for an hour or so, as in tetanus and convulsions, provided the *power-coils* are proportionally few, or the application is not near or about the head. But the powerful primary current of *both quantity and intensity*, such as produced by a Daniell's or a Smee's battery, has so much *chemical* effect in living tissues, that — although perfectly safe, and highly useful, when applied for given cases, and by a precise *method*, for only a fraction of a minute — we must ever be reminded that *the long-continued application of such a current to the human organism is not safe, and is not its correct or philosophic use*; but in all the minute details of *current direction*, whether this way or that, applies equally well for all the primary galvanic currents, as for all the secondary or Faradaic currents.

B. NOTE 1. Experience leads me, of late, to conduct the electric treatment for many of the cases of neuralgia, rheumatism, "*sciatica*," and other *pain-causing conditions* of the nerves, muscles, and joints of the "lower limbs," — i. e. such as are not inflammatory, — under one of two general rules: —

RULE 1. *For Pains in the Lower Limbs in Obstinate Cases.*— Where the painful limb is *cold* and soft, or lean, and with poor circulation, and particularly if the pain, stiffness, and weakness is about the hip and thigh, and mostly or *only above* or *about* the knee joint, — the foot and ankle being weak, — in all such cases apply the current in a *direct* or *down-running* direction; always observing, in these cases, one other of my rules for neuralgic affections, viz.: to commence the application with the utmost caution and gentleness in every possible respect; also using only large, fine, soft, and moist sponge electrodes, (see pages 387–389,) one of which (the *positive*) is to be placed, according to the nature of the case, over the exit of the great sciatic nerve, or under the coccyx, or a little above the second lumbar vertebra, or else *occasionally glided* from the one place to the other, searching for the most tender spots, over and about which, when found, this electrode is to linger; and at the same time applying the other (*negative*) sponge into the popliteal space back of the knee joint, where it is to be held for, say, 30 or 60 seconds, with a gradually increasing current; then gliding it along, so as not to interrupt the current, on to the external *peroneal* nerve trunk, in like manner; then move it along over the *extensor digitorum* with a full bearable current; then wiping it over the whole calf of the leg for a minute or so more; then on to and about the outer ankle joint, and so on to the roots of the toes, first above, then underneath, but without once intermitting or reversing the current. Here let this electrode rest; and now commence gliding the other, upper (*positive*) elec—

trode downwards, from stage to stage, mostly following, and pressing it over, the course of the affected nerves, but also wiping it over the muscles of the thigh, and about the knee joint, on its way down, terminating the *seance* by working the sponge down to the ankle. If there is *arthritic rheumatism*, then pass a strong current also *through* the affected joint, in a direction downwards and outwards, and so maintain it for some minutes. If, however, the pain, soreness, weakness, or contraction is rather on the anterior and inner side of the thigh, then proceed as before; but, *from* the abdominal ring, crest of ilium, or exit of the great femoro-crural nerve, *to* the inner side of knee joint, for some time; then to the inner calf of leg, ankle joint, and inner edge of foot. Carry out these principles in all similar cases. If the case is a mixed one, or is not benefited by some three, or four, or half a dozen sittings, then try, or pursue the plan laid down in the next rule; but observe only the one rule or the other throughout any one seance.

RULE 2. *For Pains in the Lower Limbs.* — When the painful limb is plump, solid, and *warm*, i. e., when the tissues appear to be well nourished, particularly if the pains occur mostly or *exclusively below* the knee or ankle, or along the calf of the leg, or in the foot, — then, for such exceptional cases, in order to be successful, we are obliged to apply the electric current, during the seance, in an *inverse* or *up-running* direction; always observing the same precautions, and usually first trying the method laid down in the foregoing rule. For these cases we must, therefore, plant the *positive* sponge electrode at the root of the toes, while the *negative* is at the same time directed to the external *peroneal* nerve, or inner condyle of the knee, or popliteal space; and so gliding it on over the *vastus externus*, and *gluteus*, to the great *sciatic* nerve trunk, or to the lumbar region; or else over the *rectus femoris* and *adductors*, to the *crural* nerve trunk, and from there to the lumbar region. Thus, at one of these places, let this *negative* electrode now rest; while, with the other, we proceed to work gently upwards, from half minute to half minute, from the foot, over the ankle, to the knee, and so on over the thigh muscles; and while here, the *negative* should be removed to, if not already at, the lumbar region, while the *seance* is being finished, by working the *positive* up to the groin, or ischiatic notch, and there retaining it a little, the whole occupying 5, 10, or 15 minutes. Let this be repeated daily, or every other day, until the patient is quite restored.

RULE 3. *For Pains in the Upper Limbs in Obstinate Cases.* — Neuralgia, rheumatism, and other *pain-causing conditions* of the nerves, muscles, and joints of the shoulder, arm, and hand, must be treated much on the same principle as already laid down, under two *rules*, for sciatica, &c., (for which see at B., RULE 1.) If, therefore, the case presents a painful shoulder or arm, that is *cold* and soft, or lean, particularly if the pain or lameness is *mostly* or *entirely* about the shoulder, upper arm, or elbow, in such a case apply the current in a "*direct*" or *down-running* direction. First, plant the *positive* sponge electrode on the cervical spine, while the *negative* is being directed over the

*brachial plexus* for a minute; then glide it along down the *pectoral* muscle to its farthest extent; then over the *median* or the *ulnar nerve*, near the elbow joint; then glide it along down the outer side of the fore-arm, to the back of the hand but a little below the wrist joint; then wipe it over the extensor muscles on the back of the fore-arm; and then in like manner over the flexors. Next allow this *negative* sponge to rest a little first in the palm of that hand, and then on the back of that wrist joint; and at the same time commence moving the upper or *positive* sponge that has been on the upper back, and with it bathe over all the shoulder, neck, and pectoral muscles, and then also those of the arm, down to the elbow, and particularly over the trunks of the median, ulnar, and circumflex nerves; and so finishing the *seance* by working the electrode down below the elbow joint on the fore-arm, while the other is still at that hand. If there is a *rheumatic* affection of the joint of the shoulder, elbow, or wrist, then pass a smart current *also through the affected joint* transversely, or rather obliquely, and mainly downward and outwards, for some few minutes more at each *seance*.

RULE 4. *For Pains in the Upper Limbs.*—If the patient presents a painful arm that is plump, firm, and *warm*, with good circulation, and more especially if the pain or lameness is *below* the elbow, and about the wrist or hand, then for such like cases, if the previous rule has been tried and failed, then apply the current in an *inverse* or *up-running* direction; always bearing in mind my fundamental *neuralgic rule* regarding careful manipulation. Commence this *seance* by first planting the *positive* electrode over the *median* or *ulnar* nerve, near the elbow; then, with the *negative* sponge, commence bathing with electricity over the *deltoid*, the *biceps*, and *triceps*, and so on to the *pectoralis*, and then lingering for a minute over and about the *brachial plexus*; next wipe it over the shoulder muscles, and then let this (negative) sponge rest, or be moved a little about (not above) *the upper dorsal of the spine*, and at the same time gliding the *positive* sponge along from half minute to half minute, first about the elbow, then over the fore-arm, wrist, and hand, and then back again up the arm, from stage to stage, until it sweeps over, not only the whole arm, but also the pectoral muscles; and after lingering a minute, or so, under and above the clavicle, glide it upwards and backwards until it rests just back of the shoulder joint; then start the negative from the dorsal spine, and with it bathe over the lower spine with a stronger current; then also the *infra-spinatus*, *teres*, and *serratus magnus* muscles; thus following the course of those brother twigs of arm nerves which are distributed over the ribs on the side and lower front of the thorax. Thus ends this *seance*.

RULE 5. *For Paralysis in any of the Limbs in Obstinate Cases.*—We must know those *fundamental laws in electro-physiology*, viz., when the electrodes, with any form of electricity, are so applied to any portion of the *living* human organism that the current is direct, (down-running,) then the effect thus produced is *a modified polarity of the nerves and muscles so embraced*; also a *less nervous action*, or at least *less "abnormal"* nervous action, is obtained in the parts *at*, *about*, and *above* the *positive* electrode, while there is an *increased nervous action at*, *about*, and *beyond the negative* pole; and that if the direction of this current be reversed, i. e., so as to be *inverse*, (up-running,) then the results will be precisely the same, but in a reversed order also; i. e., *diminished* action below, and *increased* action above; moreover, that this effect is greatly increased, if the current, in whichever way directed, is now and then *suddenly* interrupted, if for only a moment at a time; and that all this is still further increased in effect, i. e., far more extensively and profoundly disturbing and impressing the embraced nerves, if not the whole nervous system, by *suddenly and repeatedly reversing the current*,

as well as interrupting it, and that in direct ratio to the intensity of the electric current so employed, and inversely to the want of susceptibility in the organism, or hinderance to the inworking of the current. Therefore, these being facts, for paralysis we are to direct one electrode — whether moist sponge, or metallic plate or ball, covered with wet cloth or buckskin — to the fleshy part of the affected muscle or muscles, while the other is planted over the large nerve, whose branches ramify that muscle, and thus run the current in a *direct* manner, from quarter minute to quarter minute. Let the *breaking* of the current be *suddenly* done, at the *switch*, or binding screw, and not by lifting off the electrode from the skin. So let the *reversing* of the current be done by the *switch*, or by exchanging the *contacts* with the electro-magnetic machine, or by the *key-board* of the galvanic battery, — i. e. metallic, — and not by exchanging the electrodes. Thus, for a few minutes, work up the polar molecular mobility of the affected nerves and muscles, and then for a few minutes resort to Faradaizing, not only the sick nerves and muscle, but also those adjoining, or even the whole limb; and thus alternately operating, more or less long and severe, at each *seance*, according to the strength of the patient and the effects produced. When we still suspect or fear EXISTING central disease and source of the malady, (although in doubt, or even hoping to find a better state,) then we must *not* resort to any *reversings* of the current, nor even to *sudden* intermittences; at least not to risk this until after trying several applications *on general vitalizing principles*; such, for instance, as laid down for hysteria, and for atony of the abdominal viscera, &c., (for which see Rule 14, p. 469.)

Thus we can operate on a case so as not to disturb very much the central organs, i. e., the *brain* and *spinal marrow*, if we but employ gentle and moderate *direct* currents, as under *neuralgic rules*; but we make somewhat more effect if we *suddenly interrupt* the current, or twitch the muscles by it; and we make more *central* effect still if we also *reverse* that current, and still greater effect if the current is directed considerable of the time *towards the head*, particularly if the *negative* electrode is about the neck, or *near the head*; and the effect is heightened still more if such a current is occasionally interrupted and reversed for a little, but *maintained mostly in the up-running direction*; and the profundity of every such impression is, moreover, in direct ratio to the strength of the electric current employed.

If, therefore, any portion of the arm or hand is paralyzed, we must first place the *negative* electrode on the *brachial plexus*, or nerve *medianus*, and with the *positive* work a strong current over the neck, cervical and dorsal back, as well as over the pectoral and shoulder muscles, for a few minutes, and then, placing the *positive* stationary on the plexus or nerve, proceed with the *negative* to make such oblique passes and such interruptions and reverses of the current over the affected muscles as will bring them into full action. This may be followed up by Faradaization, at the same *seance*, with good effects.

If any portion of the leg or foot is paralyzed, we must first place the negative electrode over the exit of the ischiatic nerve, or over the femoro-crural nerve, (according to the affection,) and with the *positive* proceed to bathe electricity over the whole spine, back muscles, and bowels, using a smart electric current. After this, place the *positive* electrode stationary at one of those great nerves, and with the *negative* make such oblique passes and current reverses over the fleshy parts of the sick muscles as to cause them to freely contract; but always aim to bring this about with the least possible pain.

RULE 6. For *electrifying* any muscles, on the limbs or body, painlessly, take but one electrode in the hand, while the other electrode is at rest over the nerve-trunk, (as directed in the foregoing rules,) or else *take one electrode in each hand*, which is my more usual practice, and proceed to adjust, waver, or glide the one, or both of them, as necessary for diagnosis or for treatment. Even when working *team-electrodes*, that is, moving both along together parallel and simultaneously, if they are the large sponge electrodes, it is better so to hold and control them. But for performing Dr. Duchenne's method of *faradaization*, that is, when working a strong current through small, oval, or pointed *metallic* electrodes, for "*localized faradaization*," (reflex influence?) then we are to follow Dr. Duchenne's advice: *take both electrodes in the same hand* — apply, retaining them perpendicular, to the skin, or moving them along near together, parallel and simultaneously.

RULE 7. (For *general* rules, insisted on by the author, see pp. 427 to 437.) For "*tic douloureux*," i. e. after correcting the faulty function, or whatever is the provoking cause, — so also for *rheumatic face-ache*, periosteal jaw or tooth-ache, earache, for diffused hyperæsthesia, or peripheral neuralgia, &c., — the best method to be pursued in these cases is, to begin by placing the *negative* sponge electrode down inside the loosened dress to the pit of the stomach, or better still if to the lower umbilical region; then with the *positive*, a fine moist sponge, conveying the most gentle or even imperceptible current, and if electro-magnetic, let it be of the finest vibrations possible, — thus commencing on the side of the neck, gliding it about there thoroughly, then along up to, and a little in front of, the ear, and then on to the face, by wiping it over as if washing; then work back again to the neck, and now gradually increase the current while there, lingering some at and about the exit of the *portio dura*; then working the sponge along upon the face again, with the stronger current, by gliding and hitching motions, — say every quarter minute, — and thus for some 5 minutes, lingering mostly about or over the most painful spots. If there is then still any decidedly painful or tender spot left, choose a smaller sponge-tipped electrode *positive*, and plant it moderately firm *directly on the site of pain or soreness*, which is most likely to be found at the *supra-orbital* or *infra-orbital* nerve exit, and retain it there for 3 to 5 minutes, with all bearable current, — be it more or less, — until the pain and soreness are completely chased away. Always avoid touching the forehead with an electrode, because the periosteum of the bone is so near the skin that more pain is produced than relieved. I usually finish such a *seance* by wiping the larger sponge electrode again a few times over that side of the face and closed eyelids, and then passing it on to the side of the neck for the last minute. Now, if the pain returns at any time within 6 hours, repeat the treatment. If it does not return within that time, it is probably cured. But if it persistently returns, time after time, in spite of this treatment, you in all probability have not corrected the functional or habitual *cause*, or else you have in that case organic disease.

RULE 8. (See pages 432, 443, 529, 550.) My experience in the treatment of *cephalalgia*, or *head-pains*, and the various "*ugly and disagreeable feelings in the head*," those that occur *at the back of the head and neck*, arising from what I conceive to be *a "disguised" neuralgic condition of the ganglionic nerves in the head, or of the occipital nerves*, (but sometimes from this unrecognized condition of the *supra-orbital* nerve,) leads me to advise, as a general rule, to first pass the large sponge *negative* electrode well down the back, inside the loosened clothing, or else up under the clothing from below, so as to be beyond the cervical ganglia; and if as low as the *cauda equina* (second lumbar) is better still; then with the other large moist sponge *positive* electrode, commence over the cervical region, increasing the current to all that is bearable, (painless,) and thus wiping over the whole *sides* and back of the neck, slowly back and forth, without much rest, as far as to the shoulders, for some few minutes; then resting it from half minute to half minute, at or just below the most sore or sensitive places, at the base of the head, close to the hair, back of the ears, and on the posterior edge of the *sterno-cleido mastoideus* muscles. If the person is not nervous, and the first few *seances* do not better the case decidedly, then for once apply at a future sitting the large sponge *positive* electrode, and only a very gentle current, *to the crown of the head*, and upon the *parietal* protuberances, through the parted hair, where the spots must also be a little wet; retain this current and site of electrode some 2 or 3 minutes only, *well back* upon the top of the head. Moreover, sometimes change the site of the *negative* electrode *to the epigastric region*, while directing the small sponge *positive* to the *supra-orbital* nerve exit; also while more strongly bathing the neck and shoulders as before; *but never while the positive electrode is on the top of the head.* In this latter case — a procedure I seldom resort to — the *negative* must be somewhere down the back.

RULE 9. (See pages 432, 443, 1015.) *For operations about the eyes with electricity*, for "*heaviness*," *weakness*, premature "*poor sight*," or *paralysis* of eyelids, or for partial *amaurosis*, &c., we must proceed very differently from the method laid down in Rule 8. Here, we have diminished nervous action; there, was exalted nervous action. True, I usually commence the *seance* by placing one electrode first at the epigastrium, and then at the lower cervical back, and with the other medium-sized sponge begin wiping over the closed eyes, face, and temples repeatedly, but as carefully avoiding the forehead; first with this electrode as *positive*, while searching for pain, tenderness, and the *bearableness* of the case; then with it as *negative*, for a minute or so longer; and if the current is electro-magnetic, let it be gently increased as strong as can be used, without producing pain or any kind of suffering. For some cases, both the electrodes can be applied to the eyes, and exchanged back and forth, with good effects, in working up the nervous tone and muscular response. This may become still more effective by reversing the current by the *switch* or *pole-changer*, instead of exchanging the site of the electrodes. Next we are to exchange the large or medium sponges for the more delicate

ivory electrodes, whose pea-sized sponge *tips* are wet with clean water only. These are to be placed — the one at the outer and the other at the inner angle of the closed eye, above or below, so that the current may traverse the nerve branches that ramify the *orbicularis palpebrarum*, as well as the fibres of that muscle, and the eyelids, and other tunics and glands about the eye, *when the electrodes are held lightly* ; or through the deeper parts, and the eyeball itself, *when these electrodes are more firmly pressed, so as to embrace the globe between the poles.* This effect is still more profound, if they are planted firmly at the outer corner of each eye, and the current is suddenly reversed; and still more so, if the positive electrode, a large sponge, is placed at the back of the neck, while the other, a smaller sponge, is pressed upon the eyeball, so that the current passes through the closed eyelids; and this is still greater, if the current is occasionally — say every quarter minute — suddenly broken and *reversed*, for a second or so, but *maintained mostly so as to run from the nucha to the eye*, thus producing true ganglionic reflex action.

RULE 10. (See pages 274, 435.) *Operations about the genital organs.* For electrifying the rectum, urethra, bladder, vagina, or uterus, as required for cases of *atony*, or weakness, for *prolapsus*, *enuresis*, local palsy, &c., we may employ long, slim, insulated silver, or glass, or gutta percha electrodes, with sponge or silver tips, made expressly for these purposes, and which, for such cases, must be connected with the *negative* pole. (See page 1071.) The other, *positive* pole, may be a moist sponge, which, with a moderately brisk current that is often intermitted, and occasionally but for a moment *reversed*, (see cuts on page 389,) is to be moved, every quarter or half minute, up or down the back, in short stages, and in an elliptical order, (see Rule 14,) i. e. up one side of the spine, and down the other; then *vice versa*, and so over the roots of all the spinal nerves, *and their respective ganglia;* and finally along the sides of the body, and over the abdomen, during this part of the *seance.* Next, exchange the *internal* electrode for a surface sponge electrode, still *negative*, and by bringing the two near together, make them to promenade up and down the back a few times, with quite a strong direct current; then move them in small double circles over spine and back muscles; then, leaving the *positive* at rest on the back, or rather now and then moving it a little, proceed with the *negative* to bathe over the lower bowels, with very sharp currents, for some time, and so finish this *seance.* I should have said that this latter procedure has been my most successful method for *atonic Amenorrhœa.*

RULE 11. When the aid of electricity is resorted to in midwifery practice, as it is and can be most judiciously and effectively performed any where, and by any earnest practitioner; for instance, as for those cases where "the waters have broke," and hours have elapsed, and yet, notwithstanding the hot tea, the *room promenade*, and a well-dilated *os uteri*, still the labor does not set in in earnest; or where the pains have been for some considerable time "*grinding*" and unavailing, the harassed patient and every one else is being "*worn out*," and yet the labor has scarcely progressed; also in those cases of

*tedious labor*, just as the moments arrive when it becomes evident that the powers of the patient must soon fail, or be speedily and effectively aided by this force of nature, (electricity,) or else by ergot or instruments, or by all these, and more; so, moreover, in *post partum* "*flooding*," when occasioned by *atony*, want of vitality, or excessive fatigue of the womb and abdominal muscles; thus, wherever it is desirable to promote tone and *true* "*labor-pains*," let the woman lie upon her side, while the operator, with a *brisk working* electric machine, (electro-magnetic, or magneto-electric,) takes his position with a large sponge electrode in each hand; the one, *positive*, is passed to the upper spine, from whence it is to be diligently moved about over the whole back and ribs, sides and breasts, while the other, *negative*, is directed to the abdomen; and thus with the two, separately performing the double circle movements simultaneously, (see Rules 13 and 14.) the one on the back and thorax, the other over the abdomen; which latter is to be moved in short stages, and so swept well about the gravid uterus — *not continuously*, but from half minute to half minute — for some three or four such moves, (or until a true pain is induced,) and then give a recess of a half minute or so; and then repeat it in like manner, and so on, again and again, until true *labor-pains* are established, or the desired object is obtained. Sometimes the electrodes may be placed to advantage, so as to embrace the projecting abdomen transversely, obliquely, &c., for a little, but mostly as just advised. Sometimes it is important to trust one — say the electrode on the back — to the hands of the nurse, that the accoucheur may have one hand free. Where there is *no contra-indication*, the effects of the already strong current is greatly increased here, by a *sudden, occasional, and momentary stopping and reversing the current*. (See page 463.)

RULE 12. *Not so* must we proceed, if the affection, on the contrary, is a *painful, irritable*, and probably a rheumatic, or a neuralgic one; for then we must invariably connect the abdominal, or *internal* instrument (electrode) with the *positive* pole, while the *negative* sponge is now directed to the terminal twigs of the femoro-crural nerve, on the inner side of the knee joint, — first on one, and then on the other; also moving this one about occasionally upon the thigh muscles, but without shock, — i. e. without producing a break in the current, — although it is well to vary its strength during the *sitting*. Neither is it always necessary to resort to the internal electrode for these cases. Indeed, I think I can safely state, that in the great majority of cases the treatment has been completely successful, where it was conducted with *only* the large moist sponge electrodes, the *positive* of which was directed to and about the lumbar region, the crest of the ilium, to the abdominal ring, groins, and thighs, and so terminating each *seance* while working both electrodes as low as the knees or ankles. Thus we are enabled to employ a very much stronger current, and also spare the moral feelings of the patient. Therefore I would further say, that for pains, weakness, "*ugly feelings in the small of the back*," or on the sacral bones; for neuralgia of the spermatic

cord, testicle, scrotum, bladder, &c., in the male; or of the fundament, labia of the vulva, urethra, vagina, uterus, or ovary, in the female; as also for neuralgic lumbago, and for *dismenorrhœa*, (see page 933,) we are to commence the treatment by placing the *negative* electrode low down on the inner side of the thigh or knee, while with the *positive*, directed to the *cauda equina*, (second lumbar,) we perform circle movements on and about that part of the back for a minute or so; then removing the *negative* to the outer side of the thigh, and increasing the current, glide the *positive* up and down the whole back, about the loins and abdomen, until all pain, tenderness, and lameness are entirely wiped away. Next, return the *negative* to the inner side of the thigh again; and now pass the *positive* over and below the crest of the ilium and lower flanks of the abdomen, — lingering or working most, near, about, and over the most painful or tender spots, with a lively current, but not so as to cause much pain. Next, work it on the groin, inner and upper part of the thigh, and so on downwards, cautiously watching for any expression of new-caused pain; for this must be avoided. If, after several such treatments, there is obtained no substantial relief, then, perhaps, we are justified in also entering the private organs with suitable electrodes. This should certainly be done in the more obstinate cases. But I maintain that we may very much more frequently succeed without this last resort. This is peculiarly true as regards *amenorrhœa*, under Rule 1; and of *dismenorrhœa*, under Rule 2.

Rule 13. (See page 427.) *Circle Treatments.* — Some of my most valued and frequently resorted to *methods* of manipulating the electrodes are termed the circle movements. These are performed, for specific ends, in several different ways: first, by the *single circle* movement, — i. e., usually done by one electrode, while the other remains stationary, — the *positive* being planted in the centre of the circle-making *negative*, or else situated more or less distant, according to the anatomy and the affection; or by *double circle* movements, — i. e., both electrodes are moved in circles, — the *positive* in a small circle *within* the larger circle of the *negative*, as if about a common centre; or by *alternate circle* movements on separate parts; or by *simultaneous circle* movements, — as for instance, where one, *positive*, electrode is on the back, while the other, *negative*, is on the stomach or bowels, performing smaller or larger circles there, and alternately, or at the same time, the former is moving elliptically up and down the back, or over a portion of it. Thus it is seen they accomplish specific purposes, and for the given case one cannot be substituted for the other; besides, we are thus enabled to very surely bring under the searching influence of such gliding and gently varying — although pretty smart — electric current, all the muscle-fibres, through and together with the nerve trunks and their depending branches, as each becomes successively embraced between the two relatively changing electrodes, or as they receive the influence — within or beyond — of the sweeping electric radius.

There is another *double circle and seesaw method with team-electrodes*, that we often employ, as in Faradaization; as for *dermatalgia*, or neuralgia of the

skin, and for hyperæsthesia of the sentient nerves. For this the electrode must be small, and the electro-magnetic current must be as sharp as the patient can possibly bear. (See Rule 19.) *Team-electrodes* is merely a term I employ to signify that mode of holding and moving two small electrodes in the same hand, with only a finger or two between them, as first performed and described by Dr. Duchenne, in his *localized Faradaization.*

RULE 14. (See pages 928, 954.) *The General Tonic, or Vitalizing Seance.* — This was instituted by me at first only for cases of general debility, incipient decline with weak chest muscles, and nervous cough; for emaciated children, and young persons with cold skin and poor circulation, as after severe sickness, and for *general hysteria.* But the past year or two I have found it also *the treatment* for rachalgia, "*irritable spine,*" rheumatism of the vertebræ, and hyperæsthesia of the back muscles, as well as for atony of the abdominal viscera, for constipation, &c. (See *law* of electro-physiological action, on page 921.) The patient is seated upon the ottoman or stool, and the operator takes his seat behind him. The *negative* electrode sponge is first directed to the umbilicus, or, if a female, to the left ovary, perhaps, while the *positive* moist sponge is firmly held, and slowly glided over the whole back, shoulders, and thorax, for a few minutes; then increasing the current still more, (*more* in proportion as the patient is *less* nervous,) carefully, but considerably, and now moving the two electrodes all the while in less or greater circles, the one on the back, shoulders, or thorax, the other on the abdomen or thighs, and otherwise modified to the case, — *but always observing the same relative current direction,* — thus *depolarizing* the roots of the spinal nerves when exalted, and arousing the peripheric nervelets when diminished, and calming or "*modifying*" the great chain of ganglia in the sympathetic department of nerves! Now, the evidence that this or its equivalent is obtained, — whatever it may be termed, — is the almost uniform fact, that after such repeated sittings, either alone, or as aid, or aided by other judicious medication, the ovaries are found not so sensitive, and the catamenia flows more promptly and easy; the bowels are not so tardy, muscular tone is awakened in the abdominal parietes, — i. e., there is not that baggy sensation, or constricted condition of the abdomen and its contents, — digestion (and secretion?) is invigorated, and there is evidence that the muscles of the back and sides, as well as the vertebræ and ribs, are less sore, less tender to touch or pressure, and the whole body and limbs are less lame, and not so "*tired;*" and if there has been hysterical or hypochondriacal manifestations, they are vanquished. The patient shows more interest, courage, and purpose of will or resolution, as well as powers of endurance. In a word, so uniformly is this the result of a few weeks of such electric treatment in suitable cases, that we here urge its use, by competent practitioners, as a most valuable adjunct medication, and well worthy of patient investigation, and improvement or adoption.

RULE 15. (See page 433.) For *Thoracalgia* and *Infra-mammary Pain,* take the following method: First place the *negative* electrode at the

lower umbilical region, then with the *positive* sponge commence under the clavicles, bathing over the pectoral muscles, for a minute, and then over the whole thorax; mainly, or only, I should have said, on the *anterior* portion of it, — employing only medium strength current, and working *at first round about* the sore or painful places, then on to them, as well as about them, for 5 or 6 minutes more, or until all pain and soreness is chased away, so as not to be reproduced by full inspiration. Repeat the same daily a few times.

RULE 16. (See page 433.) For *Epigastralgia*, and pains simulating dyspepsia, adopt the *double circle movements*, by placing the *positive* moist sponge *near* the tender spot over the stomach, while the other, negative, is placed somewhere below, on the abdomen or thighs, — i. e., far away, and that in a downward direction, — and thus commence moving both electrodes in circles, the one close about, and afterwards over, the tender stomach, while the other is performing a large part of a larger circle, and that mostly in a downward direction, which is to be continued for 5 or 10 minutes. The *positive* sponge must be moved as gently but as firmly as possible, without producing pain. Repeat this *seance* daily, or every other day.

The foregoing rule, with the use of the wire-brush electrode, is the correct *process* for many cases of *irritable spine*, *local hyperæsthesia*, *rheumatism*, and *injury* of spine or ribs, (after leeches, cups, or blisters, where is inflammation) by operating close about and over the seat of pain or soreness, with the *positive* electrode, in like manner as described for epigastralgia, — say for 5 to 15 minutes, — always observing in such cases to work the *negative* electrode mainly in lateral and *downward* directions, — i. e., to the parts anterior and below the seat of difficulty. Such is the principle.

RULE 17. *For Local Palsy of Sensation.* — First employ double-circle movements, with large sponge electrodes, the negative in the centre, so as to exercise the underlying muscles. This may occupy some five minutes. Then follow with the method as laid down for paralysis in the limbs. Next, smartly faradaize the surface of the delinquent part through the wire brush. Repeat all this daily, or less often.

RULE 18. (See page 564.) For *Cœlialgia*, or pains in the skin, fascia, and muscular tunics of the *abdomen*, first place the *negative* electrode at the inner sides of the thighs, or as low as the inner condyles of the knee joints, first on one, and then on the other, while with the *positive* perform circle movements about and over the affected part of the abdomen. But here be careful to distinguish such pains, from those that arise so severely, and not unfrequently, *from atony and relaxation of the underlying viscera*, as when the intestines give way to flatus or excrements, or as where, under a morbid nervous action, there is a *secreted* flatus in the bowels, uterus, or vagina, or there may be only a want of tone adequate to the free physiology. In these cases, therefore, we must, on the contrary, institute the methods laid down at page 463, the last paragraphs.

RULE 19. For *dermatalgia*, (a neuralgia of the skin,) as also for *lo*al

hyperæsthesia, of the sentient nerves, we may proceed in some cases by the direct and profound *electrifying process* through large sponge electrodes; or by the *faradaizing process* through small metallic electrodes; and in some cases employing both — that is, instituting first the one and then the other, *at the same seance*. *Electrifying* the whole of any given part (including the skin, muscles, and nerves) is performed by using large moist sponge electrodes, and a smart current, be it primary or secondary. Apply the electrodes boldly, directly upon or about the painful or sensitive spot, and holding, or gliding them firmly, so as to cause the action to freely exercise the underlying muscles by decided electro-muscular contractions. This, whether a reflex action or not, succeeds admirably, sooner or later, in very many cases. For this purpose we are to moisten the sponge electrodes in *formula* 34. But if there is in the given case a spinal irritation or congestion, or if there is a general state of hyperæsthesia, this process will fail — as it often does, also, in persons with a neuralgic diathesis or state, who are frequently or constantly subject to transient wandering twinges of neuralgia. The faradaizing process is here equally unsuccessful. These patients require *preparing* for the electric treatment; then the remaining *local* pains, or hyperæsthesia, are readily chased away. (For the faradaizing process, see pages 426, 438.)

RULE 20. *Shocks*, or a sudden flow of electricity, may now, then, be required, as in cases of cold, insensible, and dropsical joints or limbs; or through the pelvis, as in amenorrhœa. (See p. 938.) The friction machine and Leyden jar can do this; so can the galvanic, or faradaic apparatus. With either of the latter, first adjust the large sponge electrodes, the one positive, and the other negative, all correct. Disconnect one of the conductors from its binding-screw; then set the battery to working at some high degree of speed; then touch the wire tip of the conductor to its binding-screw repeatedly, slow or fast, and as many times as the case may require. This will shock a joint, a nerve, a limb, or the whole person, as effectually, perhaps, as any ordinary friction machine, and far less disagreeably.

## CHAPTER VI.

### HYPERÆSTHESIA, — EXALTED NERVE ACTIONS AND PAINS.

By the term hyperæsthesia, this condition of the nerves is meant, viz., an exalted susceptibility to impressions; a condition expressed by tenderness; — *pain* and tenderness are its characteristics. Not in virtue of a change in the tissues that surround the nerve fibrils, and thus involving them as in inflammation; but in virtue of a change that is limited to the nerves, in some part of their route from centre to periphery. The pain that arises from a morbid state of the *nerves* only, and the pain that arises from a morbid condition of the *tissues*, to which those nerves minister, are, therefore, expressive of two widely different morbid states: the one is neuralgic sensibility, the other is the pain and tenderness of an inflammation. Being thus widely different in their nature, they require a widely different treatment.

The correct diagnosis of the two conditions, and a true estimate of the value of the given pain and tenderness, as leading symptoms, are of the very first importance. The seat of neuralgic *pain* is frequently in the termination twigs; but that is rarely the seat of the *cause*. It is to the trunk of the nerve, or to the sensory tract of the cerebro-spinal axis, that we must look for this. In the pain of inflammation, the cause is local; and when it is external there are tumor and rubor. The morbid condition, giving rise to hyperæsthesia, may be seated in the nerve fibril, or in the central axis; and it may be either primary or secondary. Any cause which *exalts* the sensorial function in either point, gives rise to hyperæsthesia, as a mechanical injury or contact, or congestion of the neurine. Nerves of sensation passing through *foramina* in the bones, or *winding around bones*, or *tendons*, are peculiarly liable to the first-mentioned causes. Hence the nerves of the face are so much more frequently neu-

ralgic than others. *Spicula* of bone, or of cartilage, or analogous deposits in or on the sero-fibrous envelope of the spinal cord, are of this character. With regard to other causes of hyperæsthesia, *the most frequent*, and most important, is a propagation of irritation from the peripheral twigs to the central axis; then a diffusion of that irritation through the gray or white matter, so that it then involves other nerve fibrils, and a consequent extension of the pain and tenderness to other sensory nerves. We thus explain the pains experienced in the hips and thighs from congestion of the uterus. This transmission and diffusion of irritation *may be* from contiguity, as in the case just mentioned, or from functional connection, as between the mammæ and ovaria, or uterus; or the sympathy may arise between parts deriving their innervation from a common system of nerves, as the uterus and stomach. Hence the anatomical and physiological relations of the organs affected must enter largely into our consideration, when establishing the diagnosis between neuralgic and inflammatory pain and tenderness.

*Hyperæsthesia* is a term we usually apply to an exalted irritability of the sensitive surface-nerves of the skin. But it must equally apply to, or embrace, *this condition* of those nerves that supply the mucous surfaces; to this condition of the nerves of special sense; and to those of the deeper-seated structures, for there may be a hyperæsthesia as well as a true neuralgia of the ganglionic nerves, and hence of the organs they supply. It is a symptom, as well as a disease, of much diagnostic importance wherever it occurs, for it is most desirable in every instance, if possible, to separate its phenomena from those of inflammation.

Hyperæsthesia is, in one sense, a form or modification of neuralgia, and probably constitutes a part of the character of many local nervous affections, such as cephalalgia, gastralgia, &c. It is not neuralgia, strictly speaking; yet it is truly a too acute, and often a painful, nerve-action, but not in twinges or paroxysms. It constitutes that part of the *exquisite sensibility* of the skin we find in tic douloureux and hemicrania. It occurs also in hydrophobia, and in tetanus, and can be produced by strychnia. We often find it with gout, and with rheumatism, but more frequently with those maladies termed *hypochondriacal* and *hys-*

*terical.* It sometimes appears as evidence of some internal irritative disease; as tumor pressing the spine, or on the *pons varolii* and *corpus quadrigemini.* It also sometimes results, directly or indirectly, from an injury of a nerve-cord.

Hyperæsthesia is, then, *usually*, to be understood as *an excessive cutaneous sensibility*, which may occur in two conditions; and either of these may or may not be attended with excessive sensibility in the motor or muscle-nerves, termed *muscular hyperæsthesia.* In one class it is but the symptom of lesion of the nerve, or of the nerve-centre. In the other class, it is simply functional; and this class is quite curable by electricity and adjuncts. There are *three modes* of effecting this; and *one* is, by benumbing or overwhelming the undue and exquisite sensibility by the peculiar effect of Dr. Duchenne's method of using electricity, viz., "*localized faradaization;*" using a very highly intense faradaic current, applied, through small metallic electrodes, on the dried skin, directly over, all over the affected part. This is to be continued for several minutes at a time, and repeated daily until a cure is effected. The *second method* is, by a revulsive action, through the same means, but applied *only in the neighborhood* of the affected part, or on a remote part.

The *third method* is, through a change of polarity *induced* in the supplying nerve-cord, by causing to pass down it a steady current of primary galvanism, or the *extra*, or else the ordinary induced current of faradaism, in a down-running direction, steadily and constantly, during the seance of five, ten, or fifteen minutes. For this third method we are to employ large, soft, moist sponge electrodes, and to apply them rather over the course of the nerve-trunk a few inches apart; or, while one negative is on the utmost nerve terminals, at rest, the other, as positive, is made to glide along over, up and down, the course of the nerve during the seance.

For all these methods, where we employ the faradaic current, the vibrations should be as fine, or rapid and uniform, as possible; and for the first two methods the current should be of the greatest strength and highest intensity possible that the patient can bear; excepting it be an hysterical patient, in which case it is to be rather prudently used, for fear of producing the fit. There

should be produced, by either of the first two methods, a burning pain, which, if the application has been thoroughly performed, is immediately followed by a feeling of numbness and an agreeable sense of relief. In some cases only a temporary relief is thus obtained; repeat, with *formula* 12 or 25, to alternate 34. But in many cases I have seen a complete cure; some after only one, two, or three sittings, and others after quite a number of seances, daily followed up until decidedly relieved. Then quitting the electricity, and the too much sensibility and pain also quit. But she must be advised to keep the stomach and bowels free, and to leave off taking whisky toddy to make her sleep; or, if the patient is a man, he must be advised to avoid tobacco, and every other stimulant also, and to obviate every nerve-*enfeebling* labor or indulgence.

*Delirium Tremens.* — A hyperæsthesia of the brain is a complaint usually found in intemperate persons, and has three characteristics: there is a peculiar delirium, there is trembling, and there is sleeplessness. But we may occasionally see an affection precisely like *mania a potu* in persons whose nervous systems have been racked by persistent mental anxiety, or who have long used opium or other drugs to lash the flagging brain. Generally, however, delirium tremens is brought on by the use, or abuse, of intoxicating liquors. It is extremely rare as the result of *leaving off* the habitual use of liquors by old drinkers. The delirium, though not complete, is peculiarly busy, and without headache; but with sleeplessness, restlessness, a frequent and soft pulse, a moist and coated tongue, and a clammy skin. The sufferer notices persons and surrounding objects but partially, answers most questions in a desultory manner, and fancies devils or evil persons are about him, or that animals are crawling on the walls, or hidden behind the furniture of the room. But if restrained from getting out of bed, he is generally good natured, and comparatively controllable. Thus we may designate the case from inflammation of the brain. But sometimes there are cases that present both these difficulties; then we find a headache, hot and dry skin, pulse tense and hard; the irritability of the stomach is more marked and more persistent, and the tongue is dry with thirst. The case is critical.

In cases of pure delirium tremens the prognosis is favorable; at all events, not unfavorable in the first attack. But not so in the after attacks. If not speedily reformed, and radically so, the subject is soon marked as a drunkard, to his surprise, and inevitably dies a drunkard's death. The fatal issue, if not during a fit of delirium tremens, is soon after ushered in by a sudden inflammation of the lungs; or, after the subsidence of the urgent brain symptoms, the patient dies very unexpectedly, and a large amount of serum is found in the ventricles and sub-arachnoid spaces of the brain.

The general treatment of delirium tremens is, primarily, *to induce sleep;* to quiet and rest the nervous system; then to give nerve tonics and nourishing food. Electricity, in some of these cases, aids to these ends most marvellously, by planting the positive sponge at the base of the occiput, while the negative is at the pit of the stomach, and allowed to run continuously for a quarter or half hour. For this the primary current, twenty-five cups, is best; or the extra current, good strength; or the faradaic current, all the patient will be quiet under.

*Ecstasy*, a brain hyperæsthesia, though in symptoms the opposite of catalepsy, is nevertheless a kindred affection. In the one there is a sudden suspension of speech, of thought, of sensibility, and of voluntary motion — a living statue. In *ecstasy*, the patient is merely insensible to external objects, because of the intense thought; he is completely absorbed in some vision of his imagination, or in the contemplation of some object, to him of all-engrossing interest. The one is statue-like; the other, on the contrary, is all activity, with talk, speech, or song.

An example of this I was called to, in great haste, early one morning, not long since, in the person of a colored boy some fourteen years of age, at the time in the employ of Codman & Shurtleff, surgical instrument manufacturers, Tremont Street, Boston. He was in the act of sweeping the store when the attack took him, and in a few moments I was there, and found him thus, with broom in hand, furiously gesticulating, declaiming, repeating poetry, and screaming expressions of most exultant joy — all the while keeping time in a characteristic negro dance as extravagant as it was ridiculous. He had been perfectly healthy

and regular in his habits, and a good boy. The clerks and others about him could not restrain him. I stopped their efforts, and soon learned that he had of late been attending a series of religious meetings held by the colored people, and in which he had become greatly interested. This explained all. As soon as he was exhausted, I had him carried home, and ordered rest, and freedom from excitement for a time. He entirely recovered.

*Somnambulism.* — The subject of this affection is one who not only dreams, but *who acts in his dream as if awake*, and as if all the phenomena presented to him were real. He appears to be in a deep sleep, but acts with wonderful precision; avoids obstacles, and walks with steady gait. Yet he has not the full command of his senses or judgment, for frequent accidents do occur which are frightful, or even fatal. A person in this state will usually answer questions rationally, and with readiness, and does not appear to be at all disturbed by being questioned. But this affection only occurs in certain few persons, of a peculiar nervous temperament, and more frequently with an hysterical or hypochondriacal diathesis that predisposes to the development of this and other mysterious phenomena. Having had no experience in the treatment of such cases, I have no definite remedy to offer.

*Hyperæsthesia of the vagus, or pneumogastric nerve, especially of its œsophageal and gastric branches, is, perhaps, the most common of all neuralgic affections;* and this frequency ought not to create surprise, when we remember *how directly all mental operations act upon these nerves through the central axis* — how quickly poisons taken into the circulation react upon them — how intimate is the connection between the stomach and other viscera of the abdomen and pelvis — and how continually the nerves of the stomach are exposed to the application of local irritants. When we know that a puncture or wound of a sensitive nerve in the hand or finger will excite irritation in those of the whole limb: that from these it will radiate upon the nerves of the opposite limb, and, extending its influence upward and downward, will at last involve the trunk, and even the lower extremities, we may reasonably infer, that some such train of phenomena may occur after local irritation of the nerves

of the stomach; and that the nerves of the heart and lungs, and the sensory twigs of the upper extremities, may become involved in the morbid condition, while with the extension of it upwards, *hypochondriasis* supervenes. Common as is this class of diseases, I know of none which demand more care to establish a correct diagnosis. The most common forms of this hyperæsthesia are gastro-enteric distress, pyrosis, globus, and the "sympathetic affections of the heart and brain," termed *palpitation*, *headache*, *hypochondriasis*, &c. In persons predisposed or liable to spasmodic asthma, the pulmonary plexus will also be involved, and nervous coughs, asthma, &c., will result. These symptoms vary almost *ad infinitum* in their combinations.

*Pain in the Stomach*, (from hyperæsthesia of the *solar plexus*,) following ingestion of food, aroused by the food, or by the gastric juice, is a very common functional affection of the stomach, and is called *nervous*. It may occur, also, from *asthenic hyperæsthesia;* (for which, see *Erethism.*) The state of the tongue is very characteristic of this disease. The loss of its epithetial covering shows that the surface, particularly at the extremity, is very red; its irritable-looking papillæ stand prominently, so as to be seen; while the effect of treatment proves that inflammation is *not* concerned in the affection. The coat of the stomach is probably in like condition as the tongue is seen to be. The facts that the pain does not come on until the food has been some time in the stomach, and that albuminous food, such as requires gastric juice for its reduction, causes the greater suffering, while starchy aliments cause it in less degree, or not at all, also prove that it is not inflammation. It is, doubtless, the effect of the gastric juice, when poured out freely upon a *too sensitive* gastric membrane, producing ganglionic neuralgia. We must discriminate, also, between it and a gastric pain which is apt to occur, in some persons, when the stomach is empty; as also the pain caused by the gouty or rheumatic diathesis, or the oxalic acid state of the fluids; for this latter, the antacids, and sometimes emetics, are necessary.

*Treatment.* — For this nervous state of the stomach, and tenderness of its coats, we should daily electrify, or else faradaize

over the region of the stomach, as directed in the methods for producing reflex effect; and prescribe purified oxide of manganese, which may be given in doses from five to twenty-five grains, and repeated once, twice, or three times a day. Bismuth constipates, while this does not; we can therefore choose, as the case may require. The ordinary black oxide of commerce is very impure, and is entirely unfit for this purpose. The diet must be strictly regulated, avoiding eggs and meats, while allowing tea, wheat bread, and tapioca; and these measures must be perseveringly followed out, so that a cure may certainly be expected as the result.

If we are satisfied that the pain is owing to undue acidity, more than to nervous stomach, we know that antacids, as soda, magnesia, willow charcoal, and lime water, will give a temporary relief at any time; but for cure, we must view the acid cases in two classes: the one as characterized by debility and a general want of tone, with anæmia, or biliousness; the other class shows ruggedness, or even plethora and vigorous vitality, and full functional activity of all the organs. For the latter, *diminish* the quantity, and simplify the quality of the food and drinks; and give daily a half grain of antimony, with the eighth of a grain of morphia in broken doses. If it fails, add twenty grains of the bromide of potassium to each daily dose; and, if necessary, order also a bottle of congress water to be taken every morning, or every other morning. For the other class, the remedies must be opposite. To such, give a substantial breakfast; regular meals, very *moderate* exercise, less brain work, and more recreation; some tonic and stomachic cordial, and electrify the stomach and liver region every other day.

### *Hysteria, a true Hyperæsthesia, which may result ultimately in Anæsthesia.*

Professor Schutzenberger, in his recently published classical work on the etiology and pathology of hysteria, shows, by an array of undeniable facts, the following deductions and doctrine: —

1. That a certain *local* nervous excitement, which is generally

*continuous*, may and usually does become the organic cause of intermittent functional disturbances that are manifested either as local pain, local or general convulsive attacks, with or without the loss of sensation or motion, — one or both, — but without the central organs of the nervous system, in general, being the subjects of any permanent pathological condition.

2. That, among women, *excitement of the ovaries* is the most frequent cause of this kind of disturbance, acting much as other *reflex* actions. But it is not *invariably* the cause.

3. We recognize, clinically, the reality of this cause, since pressure made so as to be deep-seated over the ovaries will induce local pain and reflex convulsive action.

4. Other *local* irritation, or hyperæsthesia, may produce analogous phenomena; an attentive examination for which in each case may discover such centres of irritation.

5. These local irritations, capable of propagating an excitement, when simple and especially when of the ovary, are affections of *curability*, unless they have been long neglected, or are conjoined with incurable organic states.

6. In practice, it is of the first consequence to determine *the source* of the local excitement; then directly to diminish the excited condition of the nerves of the part which form the *focus* or nebulæ whence the local irritation is propagated to the system. The intermittent nervous excitement of freaks, pains, or convulsions, demands but secondary and palliative measures, ceasing as they do when the local irritation is relieved, or temporarily exhausted; unless, indeed, under the influence of the frequent repetition of this propagated pathological *condition*, a morbid degree of excitability of the spinal cord becomes *secondarily established*, and henceforth capable of being induced by only simple physiological stimuli. In this case there is an entirely new pathological condition. As regards the ovary, the original local excitement there may depend upon congestion or inflammation, on mechanical or physiological *over-excitation* of them, or on degeneration, or a purely neuralgic state. This diagnosis is worthy of our most careful search.

A grand series of clinical researches authorizes the reference

of a great number of this class of functional disturbances, occurring in the "sensitive sphere," to a special *pathological condition*, whose material element is, as yet, entirely unknown, but which is characterized by an *exaggerated excitability* of the sensitive nerves. The term *hyperæsthesia* is used to designate this condition. We clinically recognize the existence of this organic state when we find that *physiological stimuli*, or *slight causes of excitement*, produce functional manifestations in the sensitive nerves, which appear *spontaneous* or *exaggerated*. This organic condition of the individual nervous system is doubtless sometimes idiopathic, as a part of an original constitution; or it may become developed from errors. At other times it is the consequence of simple anæmia, or chlorotic anæmia. Here, too, we must attack the *cause;* and iron is the sovereign remedy — the most direct galvanic treatment possible for this peculiar state of the organism, and it should be aided by electricity.

A third series of cases reveals the existence of a more complex pathological condition. Here the hyperæsthesia is associated with a particular morbid condition of the spinal cord, unknown as regards its material element, but characterized by a *pathological excitability*, in virtue of which the *reflex* property of the organ becomes exaggerated, so that we may term this, with propriety, *reflex excitability*. At the bedside it is recognized, —

1. By characters already attributed to hyperæsthesia.

2. There is the existence of a greater or less number of *permanent centres of exalted sensibility, the artificial or mechanical excitement* of which, readily induces reflex movements in the form of convulsive attacks.

In hysteria, particularly, the muscular system must naturally be expected to play an active part; indeed, the voluntary muscles are a common "*theatre*" for the manifestation of all this troop of phenomena, whether in the form of convulsive paroxysms, in paralysis or debility, anæsthesia, or hyperæsthesia. The most condensed and practical views on this subject we find from the pen of M. Briquet, of Paris, who says, "The pains expressed in the walls of the splanchnic cavities are of such common

occurrence in hysteria, (but not here alone,) that all observers have noticed them, although failing to recognize their true source and seat. They have been usually designated as 'nervous pains,' but without any further explanation; and even the few authors who have recognized them as being *muscular* have failed to appreciate the part that hyperæsthesia of muscles plays in hysteria, or the hysterical subject. From among four hundred hysterical women who were examined particularly in reference to this point, there were not more than twenty who did not exhibit such muscular pains."*

Writers upon hysterical affections have passed very lightly over this condition, although it is so constant an accompaniment of the disease, that he thinks there is not a woman subject to hysteria who does not manifest it in one or more parts. But under the term of *hyperæsthesia*, or "exalted *sensibility*," there may be comprised various conditions formerly designated as pains, neurosis, neuralgia, or other painful nervous phenomena.

This hyperæsthesia is so easily recognized by the following signs that it is surprising it has not been sooner appreciated: —

1. The pain is always located in places occupied by the fleshy portions of muscles; or, in certain conditions, at *one end* of their tendinous insertion.

2. As the superficial muscles are those usually affected, it is felt *immediately beneath the skin.*

3. Slight pressure, or scratching with the end of the finger over the affected muscle, induces or aggravates the pain.

4. The pain thus induced is very severe, causing often cries or contortions on the part of the patient, or even an hysterical paroxysm.

5. Movement, and especially distention, of the fibres of these muscles, produce or exasperate the pain, while rest abates or relieves it.

6. Feeble electro-magnetic currents, which scarcely produce a sensation elsewhere, — i. e., when travelling through the length of a muscle that is in a normal condition, — will induce an

* Medical Times and Gazette, 1858, p. 568.

amount of pain that is difficult to bear while traversing the hyperæsthetic muscle, and becomes quite intolerable when the current is made a little stronger.

7. Under the influence of proper Faradaization, non-inflammatory muscular pains, including also such as the rheumatoid, and those of lead-colic, and especially those arising from a pure hyperæsthesia of muscles, (in men or women,) are now known to be rapidly dispersed. But we find that this hyperæsthesia — which, indeed, may be termed "*hysterical myoalgia*" — is not found to affect all muscles alike; the superficial muscles, and particularly those of the trunk, being the most liable to it. In the body itself, it has its places of preference, which it observes with so much constancy and regularity as to serve for one of the diagnostic signs of hysteria. The following may be marked as its favorite seats, and succession of order of attack: —

I. *Cephalalgia.* — When the hyperæsthesia affects the muscles of the head, it constitutes what has been termed cephalalgia. So common is this in hysterical patients that, out of three hundred and fifty-six of these, it was found habitually, or at least very frequently, in three hundred of them, as affecting especially the frontal and temporal regions of the head, and, in at least nine tenths of the cases, as having its seat in the fleshy portions of the muscles. It is frequently *pulsatile;* at other times, *lancinating*, and continuing even during rest in bed, which distinguishes it from the anemic and chlorotic headache, which, on the contrary, is hardly felt except during motion.

II. *Rachialgia.* — Hyperæsthesia affecting *the muscles of the back* has been long recognized, (in men, sometimes, as well as in women.) Thus, according to the details given, it is found five times more frequent at the lower part of the back than at the upper part, and as many times more frequent on the *left side* than on the right side of the spinal column. It occupies, in general, a space corresponding to about four or six vertebræ. It usually appears here *subsequently* to the epigastralgia, and may then exist, in various degrees, from a mere uneasiness, scarcely perceptible, unless pressure be made at, and along the side of the

spine, over the severest suffering, and consequent source of disturbance of important functions. When intense, it becomes more fixed, and is then one of the "symptoms" of hysteria that is most difficult to remove, the pain recurring from time to time from the slightest cause. Its diagnosis is easy, by means of pressure made on the muscles at either side of the spine, and a little distance from it, until found, and then by observing *its usual connection with epigastralgia, and other symptoms of hysteria.* In spite of this, however, its presence has frequently given rise to the most serious errors, and a frequent one among these has been the mistaking it for an early *sign* of phthisis. What authors have described as "*tabes-dorsalis*" has most often been but this rachialgia, reacting upon the viscera, and vitally affecting nutrition, as it will, (in males as well as females.) But the most serious of all these errors is, the mistaking it for *disease* of the spine — an error Dr. Briquet believes to be even more common than Sir Benjamin Brodie has represented it to be.

III. *Epigastralgia.* — Hyperæsthesia of *the muscles of the epigastric region* plays a far more important part than has been suspected. It frequently occurs, says Dr. Briquet, as it has been noted in three hundred and seventeen out of three hundred and fifty-eight hysterical subjects. In one hundred and thirty of these, there was no accompanying derangement of the digestive functions, while, in one hundred and eighty-seven, such disturbances did exist. In answer to the question, why there should be so constantly pain in parts which seem to have no relation to the moral emotions of the patient, it may be observed — (1.) Epigastralgia may be met with in the childhood of girls who are subject to ill treatment, (*or who are constitutionally peculiarly sensitive to blame,*) or who have an hereditary predisposition to hysteria; and in such it becomes associated with disorder of the digestive organs, and a disposition to *migraine*, (hemicrania.) (2.) In others, it appears either at the period of the establishment of the menses, or later, and during difficult menstruation. (3.) In a certain number of cases, it arises amid the disturbances produced by chlorosis. (4.) In a few instances, it arises during the actual evolution of the hysteria, without the aid of any special cause. Now, the above-named circumstances explain

the origin of one half the cases of epigastralgia; and the other half is due to the two following orders of causes: —

(5.) First, the disguised or manifested hysterical paroxysms. These are usually preceded and accompanied by a feeling of compression, distention, or even tearing, and distress in the epigastric region; and for twenty-four hours after the fit is over, the patient often complains greatly of epigastric pains. In proportion to the repetition of the paroxysms does the epigastralgia become established.

(6.) Second, the depressing moral emotions. These, when at all intense, produce *painful constriction* of the epigastrium. To sum up, this muscular hyperæsthesia is due to the two orders of physiological causes, namely, the direct influence of the nervous centres on the muscles, and the reaction of the disordered stomach on the same muscles.

*Epigastralgia* extends peculiarly towards the left side, rising as high as the sternum middle, and rarely descending below the umbilicus. The pain is severe and continuous, and easily exasperated by emotion, progression, compression, or the hysterical fit. The attitude is constrained, and sometimes the respiration is influenced; but here the process of digestion does *not* appear to aggravate the suffering. The ignorance that prevails as to the seat and nature of epigastralgia has led to most serious errors in medical practice — these muscular pains being sometimes vaguely thought to be localized in the solar plexus, and, at others, in the stomach itself; and then, according to the doctrine of the day, have been treated as neurosis, gastralgia, or gastritis.

Now, if we bear in mind that, in somewhat less than half of the persons suffering from pains in the epigastrium, (stomach region,) the pain is only *muscular*, it is evident that that number, at least, have been treated for a gastralgia that had no existence. Moreover, in patients suffering simultaneously from epigastralgia and derangement of the digestive functions, the former may exist independently of the latter, and be easily relieved by means addressed specially to it; and yet, in these cases, the stomach has been needlessly tormented by treatment that, rather, should have been directed to the muscles. It is not

meant to be said that the stomach itself may not be the seat of severe suffering, such as pyrosis, tearing pain, or distention, from indigestion; but such pains are intermittent and temporary, and should not be confounded with the *continuous* pains of the epigastric muscles. The writers on gastralgia never allude to these "muscular pains;" and, since amid three hundred and fifty-eight cases of hysterical patients the author found not above ten in which gastralgia existed without epigastralgia also, it is easy to see how often the stomach has been rendered responsible for ills that did not attach to it. This affection of the muscles may continue as long as hysteria can, and persist to very advanced age. When it persists with intensity, the constant pain wears out the patient, rendering at last all active movements quite insupportable. She perhaps becomes melancholic and emaciated, and presents all the appearance of premature old age. Fortunately, we can now say, nothing is easier than the relief (cure) of this affection, under appropriate treatment.

IV. *Pleuralgia.* — Pains in the *muscle fibres* at the side of the thorax are so common, that they have been familiarly noticed by all observers, and have been confounded with the true neuralgia. The seat of the pain here is rather fixed, extending usually as a semicircle, corresponding to the fifth, sixth, seventh, or even the eighth ribs, sometimes following their direction, and at others being still more oblique. This is found six or seven times more frequent on the left side than on the right, and we find it bilateral in only nineteen of the above cases. It usually comes on subsequently to the hyperæsthesia of the other parts that have just been mentioned, it forming, as it were, but an extension of them. *Hysterical pleuralgia* can only be confounded with the pain of true pleurisy; it suffices, however, to be aware of the possibility of the former, and the then usual coexistence of epigastralgia and rachialgia, to prevent any error. It is perhaps more readily confounded with intercostal neuralgia, by which name many cases of this hysterical pleuralgia have been erroneously indicated. The distinction between these two is: First. The hysterical or muscular hyperæsthesia does not follow the direction of the nerves and their branches, but is *invariably* found at the fifth, sixth, and seventh ribs, while the accompanying

rachialgia and perhaps epigastralgia are situated quite above the points they should be, *if* dependent upon neuralgia. Second. The pain bears no resemblance to that of neuralgia, for it is excited at any point that is compressed, *without radiating along the course of the nervous tracts.* Third. Neuralgia, after setting out from this point of origin, may very soon extend to other divisions of the affected nerve. Hysterical pluralgia only shows itself *after* epigastralgia, and then rachialgia also has already long existed. Pluralgia (muscular hyperæsthesia) usually constitutes only a more or less considerable inconvenience, and however long it may persist, it is at last dispersed without inducing phlegmasia of the contents of the thorax.

V. *Thoracalgia.* — Among the four hundred cases observed critically, only twenty-seven complained of *pain in the muscles* at the anterior part of the thorax. In twelve of these it occupied only the left side, and in two, the right; while in thirteen, all the anterior portion of the chest was affected. This form of hyperæsthesia is usually one of the last that appears, and its rarity is probably due to the slight part which the pectoral muscles (wherein it is seated) take in the expression of depressing emotions. This form is not very persistent, rarely disturbs respiration, but recurs from time to time, and gives cause to much anxiety from the patients fearing that they have disease of the heart. Its independence of neuralgia may be judged by the fact that of one hundred and fifty hysterical patients with rachialgia at the level of the first six dorsal vertebræ, only twenty-seven complained of pain at the anterior part of the thorax.

VI. *Cœlialgia.* — The *muscular hyperæsthesia* of any patient is so termed when it has its seat in the walls of the abdomen. The pains of this character have long been known to authors, but they have been attributed to lesions of the sympathetic nerves, or ascribed to the underlying viscera. The author met with it in one hundred and ninety-six of four hundred cases of hysterical females. In forty-two, it affected both sides; in seventy-six, the left side only; and in thirty-four, the right side alone. This pain usually engages a considerable portion of the muscles affected, and is *continuous* while in the erect posture, being much increased by movements or pressure, but relieved

by lying down and keeping still. In many instances this affection has been sadly mistaken for painful affections of the ovary; and it is such mistakes that have given rise to the supposition that ovaritis is of more frequent occurrence on the left than on the right side. But the search for the superficial character of the pain ought to prevent this error being committed. If we first relieve the muscular pain, we find we can press over the ovary without pain. The duration of hyperæsthesia in this seat is very variable; the condition and exercise or *habit* of the genital organs, as also the amount of any sort of exertion or of repose taken by the patient, vastly influencing this result. These patients are often much distressed by this pain, being led to believe it to be indicative of some uterine disease.

VII. *Melyalgia* (a limb) is the term applied to *painful muscular hyperæsthesia* of the superficial muscles, and sometimes of the deep-seated muscles of the extremities. The existence of such pain, particularly in hysterical females, has been noticed by authors only in a vague manner. Among my four hundred cases, only fifty-eight examples of it occurred; of these both upper and lower extremities were affected in thirteen of them; the upper alone in twenty-one; and the lower alone in twenty-four. It varies in degree from a mere disagreeable sensation to most severe suffering, destroying all repose, and, if not relieved, it even gives rise to fever. In spite of the most unfavorable appearances, however, it quite disappears, sooner under the influence of correct treatment, or later, perhaps, spontaneously. It cannot be confounded with neuralgia, seeing that in two thirds of the cases the locality of the pains does not correspond with the origin of the nerve branches distributed to the muscles affected; while from true neuralgic pains arising from affections of the nerve trunks, nerve branches, or centres, muscular hyperæsthesia is distinguished by its being aggravated simply *from pressure on the muscles.*

The distinction of this affection from rheumatic myosalgia is often more difficult. The diagnosis here must be drawn from the nature of the pain and the attending circumstances. The pain in hyperæsthesia is usually excessively intense, the slightest contact causing very severe suffering; while the muscular rheumatic

pain is much less increased by pressure, and this, too, must be firmer in order to produce it. The hysterical pains of this sort are found manifested in women who have already presented other symptoms of hysteria, and they almost invariably coincide with other muscular hyperæsthesia. The emotions also exert very great influence over them; while rheumatic muscular pains usually appear in women who have already suffered from muscular rheumatism, and are in degree exasperated under the influence of *emotion*. The difficulty in this diagnosis is the greatest, where the patient is both hysterical and rheumatic, which I have often found. But then the influence, or rather *inefficiency*, of the means, which so usually succeed in the simple hysterical myosalgia, is sufficient to determine the complication of the rheumatic character of the affection in that given case.

Two important points still remain in respect to melyalgic pains. First, does it arise from any inflammatory action, or from mere *perversion* of muscular sensibility? or, rather, from a morbid sensibility of the motor nerve filaments that ramify muscle fibres? Leaving the flood of opinions written upon this subject, we will simply answer by the effects of treatment. Melyalgic pains are no ways relieved, much less broken up, by antiphlogistic remedies, only yielding temporarily or capriciously to narcotics, and can usually only be relieved by such special means as have no favorable effect upon inflammation. Second, is this pain a muscular neuralgia? This, at first, is a very natural supposition, but it is in fact unfounded. True muscular neuralgias act exactly as do the pains of nerve trunks, and are indeed *very rare* in the uncomplicated hysterical. Numerous differences mark this affection of the muscle nerves or muscle tissues, as you may choose to term it, from an exquisitely morbid or *exalted* sensibility of the skin nerves, which latter, besides other points, it is to be particularly observed, manifest the pains at the periphery of the nerves, but not in the intermediate portion; while in true hyperæsthesia of muscles the pain is felt, and can also be produced by pressure along the entire course of the fibres of the affected muscles. In this latter, pain is only felt at the part compressed; while in neuralgia it can be induced by pressure *on certain points*, and it then radiates along the

course of the branches of the affected nerve. But the best test is the effect of correct treatment; for while the muscular hyperæsthesia, which is manifested by pain, is always removable, nothing can be more obstinate or tenacious of its own peculiar display, than the fierce twinges of true neuralgia.

Finally, whenever we observe very acute pain to be induced by simple pressure of the finger on a muscular part of the body exhibiting no traces of inflammation, we may, from this very sign alone, diagnose the presence of that peculiar state of the system termed hysterical, with a very great degree of certainty. Whenever we are in doubt in these cases, we have only to gently rub with the end of the finger, for instance, on the upper end of some of the *recti* muscles in order to become perfectly convinced. Indeed, hysterical myosalgia, in some of the various forms here noticed, is, in fact, one of the most marked symptoms of hysteria, (to our own mind, though it may not always be best to declare it,) for, as it is almost never absent, it may itself be set down as a characteristic mark of this peculiar state of the system. Observation has, of late, fairly proved that it is rare not to find in these patients this peculiar muscular hyperæsthesia, either at the epigastric region, or high up on the back, or low down on the bowels, or sides, and that particularly on the left side; and, in a very great majority of cases, it appears in all these situations at once; and every female presenting this almost stereotyped series of symptoms may be most positively declared (or, perhaps, more prudently, *thought*,) *hysterical*.

From what has now been said upon the high authority of Dr. Briquet, we fear it will be well nigh inferred that "muscular hyperæsthesia" is limited to the female sex, and to cases of hysteria. By no means is this true. Most marked, distressing, and protracted cases of this malady in gentlemen of the professions, in those of close business habits, and those especially in the higher walks of life, are as familiar to the author as the class just delineated, and are found quite as amenable to right treatment, and, by far, less likely to relapse. Nor, indeed, to my mind, are all the cases that present in females (in this country) to be put down either as hysterical, or in any way connected with *uterine deviation*, as necessarily so. It is my own

observation that those painful affections of the muscles very frequently occur in both men and women, and may arise from a multitude of causes. Strong or long-continued "emotional feelings," *particularly such as are unpleasant*, or harassing, or any way nerve-exhausting, are capable of harrowing up this singular demonstration either in man or woman; and the *more impressible* the existing sensibilities or mental faculties, or the more *feeble* the muscle fibres are from want of exercise, or from over-exertion, the more liable is he or she to this painful, and, doubtless, often mistaken affection. There is not a question that the *habitual* indulgence in mere *thoughts* of venery may also produce it, and much more the habitual excess. Besides, it is no uncommon thing to find these cases complicated, or, rather, *mixed* with some rheumatismal or neuralgic manifestation, or else attended with cramps, or spasms of the muscle fibres; but this, more particularly, in females. Debility, — *debility, with nervous irritability, and this with over-mental or over-manual work, — is at the bottom of the whole.*

One other important fact should be noticed; and that is, that when this kind of pain appears to be the result of *over-exertion* of muscles, whether that was too great or too protracted, or from the muscular strength being below par, and inadequate to the task, then the seat of these pains is rather referred to *one insertion* of the muscle or muscles, but rarely to both insertions; and in that case, never to the fleshy body of the muscle. This fact, I believe, was first noticed by Dr. Inman, of Liverpool, who says that in the weak-muscled, or in the over-worked, it is not uncommon to find that both insertions of the muscles suffer equally. That it is really so, recent experience proves, though it affords no adequate explanation of the reason why. Thus, in excessive cough, one patient refers the pain to the origin, another to the insertion, of the *pectoralis major* and *minor;* one seamstress refers all her pain to the occipital, another to the spinal, another to the scapulo-clavicular attachment of the trapezius muscle. One refers her pain to the infra-mammary, another to the inguinal, and another to the semilunar attachment of the external oblique muscle. One refers his, or her, sufferings, perhaps, chiefly,

if not entirely, to the pubic, and another to the epigastric attachment of the *rectus abdominis*, while others refer their complaints equally to all these spots simultaneously, or in succession.

*Muscle Soreness and Muscle Pains are not necessarily Muscular-hyperæsthesia — are often induced from undue Fatigue or Strain.*

*Chronic Pains of Debility.* — Muscle pains may exist in the thoracic or abdominal walls, as also in the muscles of the loins, back, and extremities, *that are not* rheumatic, nor yet truly neuralgic. In some delicately constituted persons, sooner than in others, all the tissues of the body may readily become sore and painful from fatigue. Pressure of dress may produce it; a fatiguing posture, or exercise, or labor, may be the first cause, and if often repeated, it confirms this symptom into a chronic condition. Dr. Inman has recently produced a great number of cases to illustrate these facts, and to show the best treatment. He has ably maintained that very often the pains experienced in the tissues mentioned, are due to a jamming or stretching of fibrous tissue from pressure, from undue contraction, or protracted contraction. He distinguishes between the pains thus awakened in the muscle fibres, such as cramp or spasm, and those resulting from strain along the line of osseous attachment, or line of union between the muscular and tendinous fibres.

*Chronic* muscle pains, of this class, may arise in any portion of the body, more particularly in school girls and delicately organized persons, simply *from habits of posture* or *unequal rest while long sitting or standing* — at drawing, at the piano, studying, or working. If there is no support to the back or shoulders while the person sits erect for some time, the whole line of tissues along the region of the *recti abdominis* muscles and the sternum, from the pubis to the clavicles, are held in extra protracted tension, so that pain here arises; and if this is often repeated, chronic pain is the result. These cases we too often see.

If such persons are habitually sitting, on the contrary, so as to lean the side against a desk, or if the seat is uncomfortable,

or if the back rest is very low, or is too high, hard, perpendicular, and flat, then the pressure is only on the shoulder-blades or upper ribs, and this puts to protracted stretch and fatigue all the loin and lumbar muscles; or there is a thrusting forwards of the shoulders, so that the pectoralis and great serratus muscles are hampered and relaxed — producing in a feeble person, the pain-causing condition. The shoulders and arms of such delicate, enfeebled, or neuralgic persons may have muscle pains produced simply by their own weight — certainly so, if the fashion of shoulder strap or sleeve be hampering, and sustains, besides, a weight of clothing.

Moreover, we find that there is a nervous or modified neuralgic element associated with very many of these cases, so that while we may have pure cases of simple pain from over-protracted fatigue, so also we must be aware of the auxiliary pain from the stretching or compressing of a nerve fibre. There is, evidently, a limitation of latitude for labor and for rest in the human body, and each person has a scale of his own, or of her own, which must be maintained as the only law of health, strength, growth, and comfort; which being exceeded, pains, chronic pains, atrophy, and palsy supervene. This may be illustrated, in some degree, as suggested first by Dr. Jago. If the hand is stretched open as far as it possibly can be, and then held so for a little time, or, on the contrary, by closing the fist strongly, and maintaining it only for two minutes, there will be produced a disagreeable sensation, if not pain. If this were prolonged, or often repeated, the hand muscles would become painful.

And there are also other cases of muscle aches, arising in otherwise healthy muscles, simply *from want of use*. These different classes of muscle aches, muscle pains, and muscular-hyperæsthesia, must be carefully discriminated and treated by rest or by exercise; by stimulants, supports, or anodynes, as the case may demand.

*Muscle soreness* and *muscle pains* are not, then, all necessarily *muscular-hyperæsthesia;* for these conditions, we see, may arise from other causes, as from injury of spine or nerves; from debility, rheumatism, over-work, or strain. Between the three

kinds of painful muscle affections, viz., traumatic or true muscle pains caused by undue strain, labor, or protracted fatigue; muscle pains from rheumatism, and the muscle pains of uncomplicated muscular-hyperæsthesia, as I wish here to clearly distinguish *it* alone, — not calling it hysteria, — we must be able to discriminate; because the treatment proper for the one is exactly wrong for the other. The *traumatic*, the *rheumatic*, and the simple muscular *hyperæsthetic* may be found pure and distinct, or, in other cases, they may be complicated.

*The treatment* for all traumatic muscle pains is, in a word, *rest;* alterative medicines, general and local, with nourishing food, anodynes, and tonics; then, ultimately, electrifying the muscles, with deep-shampooing.

*The treatment* for rheumatic muscle pains is the same as for a similar rheumatism situated elsewhere; by iodide of potassium, electricity, &c.

*The treatment* for simple muscular-hyperæsthesia, if in an hysterical or hypochondriacal patient, or if evidently due to this state alone, should be *faradaization of the skin, for reflex effect on the centres*, alternated with exercise, deep-shampooing, air, tonics, and travelling. But if a case of muscular-hyperæsthesia is complicated with *spinal irritation* or ulceration, with disease or injury of nerve-trunk, then there must be perfect rest, spinal support, and constitutional treatment; as by *formula* 5, 12, or 7.*

"*Faradaization*" of the skin, as performed by Dr. Duchenne, is, after all, *the means, par excellence*, for all these cases, according to the experience of Dr. Briquet. By this kind of electric current, he says, *if strong, and limited to the affected muscle* for but a few minutes, the hyperæsthesia is sometimes at once dissipated; and when this is the case, even firm pressure, or movements of various kinds, fail afterwards to induce any sort of pain. Not infrequently a single application suffices; but sometimes the pains return at the end of an hour, but more commonly after five or six hours. *If they have not returned by this last-mentioned period, we may be certain that the cure is definite.* When they do thus return, the application must be

repeated as strong as can be borne, when the pain will be found to become feebler after each *seance*. If, however, after two or three fair trials, success has not in any degree attended them, the application must be renounced. The conditions for success of Faradaization with electro-magnetism are, the recent date, the diffusion, the superficial seat, and the moderate intensity of the pain. Still, as there are cases in which, though the pain has been there of old date, and success from this treatment in such has taken place, it should always be tried, for it is certainly with some chance of benefit. As a *general rule, hysterical females bear the sharpest Faradaization with far more courage than men;* but still some of them are so exquisitely susceptible, that its employment, if *urged* upon them, may even induce paroxysms of hysteria. In such cases it is recommended to let her previously inhale ether, as it in no wise impedes the peculiarly revulsive action of Faradaization. During the treatment of this affection, one grand condition must be, the complete repose of the hyperæsthetic muscles. This is, under all circumstances, of prime necessity. From ignorance of the true nature of this affection, *exercises* of various kinds have, from time to time, been recommended! Absolute repose is one essential to the cure; and a few days of such, sometimes, is of itself sufficient to relieve those pains that have resisted most energetic remedies. There should be a general or medical treatment, therefore, as well as the "*electrical.*"

### *Neuralgic or Hyperæsthetic Affections of the Joints.*

This condition, surely, refers to the nerves, not to the vessels of the affected part. As we have general affections of the vascular system, as well as local, so we may have morbid conditions of the nervous system, either as general or local. There is a *local* affection of the nerves called the neuralgic state, as tic douloureux; and I believe there is a *general* affection of the nerves as manifested in nervousness and in hysteria. But in the *hysterical affections of joints* the nervous affection is both local

and general. The pain about such joints is excruciatingly severe, far beyond what attends ulceration; but it lasts as long, and only so long, as the mind dwells upon it, and it recurs as instantly and as often as the mind reverts to it. Divert the patient's mind powerfully to another affair, and it is remarkable how almost instantaneously the suffering will vanish. These cases of simulated disease may not always be pure, — that is, without some simultaneous change of structure; but, usually, there is no sign of local disease beyond a slight swelling of the joint, and the temperature of the joint and limb is rarely changed; but not always so by any means, as heat and swelling do, now and then, attend hysterical affections of the joints and neuralgic affections generally. Dr. Skey, of St. Bartholomew's Hospital, in speaking of this, says, "We have, perhaps, in the history of mankind, no manifestation of the intimate relation between mind and body more remarkable than this — the entire and almost sudden cessasion of severe pain simply through the curative agency of a train of *healthy thoughts*."

We see, perhaps, a delicate girl suffering "very greatly" with pain in the *back*, or *hip*, or *knee*, as a mysterious *recent case;* or we see a "maiden lady," perhaps, within ten years of thirty, who has long suffered with precisely the same state as a chronic affection, — *an old case*. We are told that "the pain is dreadful" — in some cases so severe that the patient holds her body in some perpetually reclining posture, or her leg as constantly semi-flexed and immovable. In some cases, though the patient is unceasingly complaining, she still walks about, at least at times. The pain and the pseudo-joint malady are generally in the direct *inverse ratio* with other hysterical symptoms; for here the hysteria is concentrated, and the pain is increased about the menstrual period. In the earlier stages the worst and most frequent pain is referred to a spot about the *ligamentum patellæ*, which is often greatly aggravated by the merest touch, but especially if the skin and sub-cutaneous fat here situated be gently pinched up between the thumb and finger. The knee joint is more apt to be thus affected than any other, and that without local mischief adequate to account for its intensity.

The patient does not appear worn as one whose joint is ulcerating. So is the position of the patient and limb peculiar and well worthy of remark. When we see her at rest as she chooses, we find her lying slightly over towards the affected side, and the sick limb is averted so as to lie on its outer side, with the knee semi-flexed and some swollen. If we attempt to apply our hand to the knee, the girl will shrink and express suffering before the limb is even touched; and if we do touch it, or attempt to move it, she will plead or shriek and resist it instantly and most earnestly. Even the merest approximation of the hand intimating the slightest indication of a manipulative examination, is met by the instantaneous extension of both her hands, and her whole attitude and expression are those of intense fear with resistance. Such is a hysterical joint, and such cases are by no means rare.

Miss S., aged about thirty, was very sick before ten years of age, with severe cutaneous disease and fever, after which she began to feel at times a "stiffness" in the left hip joint, which was more marked from thirteen to fifteen, while at boarding school. She suffered great pain about that hip at menstrual times, and often for whole months together, when she became confined to her bed, and retained the limb in a semi-flexed position for long periods. She had had various and the best of medical advice and treatments for the last twenty years. When I saw her lying in bed, she was inclined somewhat over towards the affected hip, the limb drawn up, with the knee resting on a pillow, and the leg contracted upon the thigh. By measurement, (which was done only after most cautious, repeated, and deliberate manipulation of the ankle first, then gliding the hands along up to the knee, and while the fingers of one hand were carefully searching the contracted tendons back of the bend of the knee, and at the same time closely catechising the patient as regards sensations *there*, the other hand was glided over the hitherto *touch-me-not* hip joint, and before she was aware of it my fingers were deeply pressed, exploring the sound, deep-lying muscles about the long-fixed pseudo-anchylosed joint,) —I say that by actual measurement, it was found that the

femur was about three inches shorter than the other, and the leg on that side, from the under edge of the patella to the heel, was four inches shorter than its fellow, showing that the limb had not grown in proportion with the general development of this otherwise beautiful girl. Besides, the limb below the knee was atrophied, cold, and lifeless, while the thigh muscles were remarkably well developed, and the hip muscles were drawn together, tilting the pelvis, and largely projecting the whole hip. By any experienced and skilful eye this would be at once recognized as mainly a "hysteric-hip joint." There was no sign of local disease in progress, beyond a general swelling or enlargement of the whole hip. *Pain* — pain, not the concomitant of inflammation or ulceration, but pain *per se* — seems here to constitute the disease. These cases are said to possess, in one sense, a quality of *un*reality; but it is not to be for one moment supposed that all these patients willingly deceive their medical attendant and best friends, nor that the pain complained of so long and incessantly has no real existence. If so, why does she not complain when pressure is made gradually but firmly from the foot towards the pelvis, which would be likely to give pain in almost every other hip joint or pelvis malady? *

In fact, or effect, this disease may be *originally* produced by the peculiar circumstances and conditions of woman's life; but I believe it soon becomes a *disease of habit*, or a true neurosis, and now more or less independent of uterine action or inaction; but is rather become the peculiar contingency of the uncontrolled emotional feelings and morbid imaginations of the patient. Dr. Barwell says great harm is done by prescribing the indiscriminate and long use of steel, ethers, aloes, &c., for these patients. If this view be correct, the treatment should be general as well as *local*, and directed to the cerebral condition that produces this manifestation of pain, and to that faculty of *Will*, that sways the disease by its own or the emotional state. To control the emotions and will, is to cure the disease. Hence a plain, coarse, and *low diet*, *with plenty of regular exercise* for both body and mind, will be best calculated to break up this morbid habit and state. Let the patient have mainly plain, light, crusty

* See Dr. Walter Channing's work on the "*Bed Case.*"

bread, of wheat or rye, cold, and at least one day old, with good butter, moderate tea, and meat, with potatoes or beans once a day. She must not sleep upon a feather bed, nor yet in a heated room; is to wear flannel, and over the affected joint and limb flannels of double thickness; to apply close over the painful joint at bed time a piece of oiled silk or rubber cloth, upon the under side of which is spread a drachm or two of opium that has been rubbed up very soft in a few drops of rum and hot water; to *shock* the spine by suddenly applying at every bed time a large towel squeezed out in very cold water, which is quickly passed a few times up and down the whole spine and back, and then is to be as quickly wiped dry and got into bed for the night.

Miss S. was positively encouraged that she should be benefited, and the electric treatments were commenced, with the regimen as above. As the pelvis had been tilted over for about twenty years, assimilating and exaggerating the position assumed in true hip disease, there was double curvature of the spine from the unequal action of the muscles of the back; besides, the left glutei could be felt in strong irritative, wavy contractions, and the nates, instead of being on that side as on the sound side, was very protuberant; therefore the first business was to balance up the action of the muscles of the back and loins. The first week was devoted to this, using the primary current of galvanism. Next, the *circle treatment* was instituted over the great sciatic nerve, just as employed in sciatica or neuralgia, observing the same rules and precautions.

In three months, this lady went to church regularly, and took her daily promenade in the Mall. The atrophy and coldness below the knee was replaced with more habitual warmth, flesh color, and plumpness; the contraction of the hamstrings so much overcome that a yardstick laid upon the knee pan would touch the upper end of the rectus femoris, while the lower end of the stick would rest upon the front of the ankle above the instep. Instead of the toes now pointing to the ground, she wore a steel spring high shoe, with her little foot nearly level, and she often walks without a cane, or even a perceptible limp.

During the past fall, however, the general health of this patient had run down, and the old hip affection had become the most prominent symptom. She was again treated, but, I regret to say, with not, as yet, so flattering success; but that she will recover ultimately, and be restored to health, usefulness, and happiness, I have not a doubt.

## *Neuralgia.*

*Neuralgia* may be defined as *violent pain occurring in paroxysms*, in the trunk or branches of a nerve, of irregular duration, and after regular or irregular intervals. The pain is sometimes slight and obtuse at its commencement, and then augments in violence, becoming sharp, darting, or lacerating, which is attended with a peculiar and excessively acute plunging or constrictive sensation, which darts at intervals through the painful part. But more frequently the attack of pain is sudden, which is sometimes preceded either by an itching, tickling, prickling heat or numbness, or by slight and fugitive pains; any of which may recur whenever the paroxysm of pain is less.

It may be confined to the very *trunk* of the nerve, but as often extends itself to the integumentary ramifications, and even to the terminations of the nerves in the superficial muscles, (muscle hyperæsthesia.) Sometimes it affects only a few of the branches of a nerve, or even one or two, merely, of the fibrils.

When severe, an attack of neuralgia may be attended with tremors, or spasms, cramps, or convulsive motions of those muscles depending on the affected nerves; but there is neither redness, heat, nor swelling. When these latter phenomena do occur, it is a more or less *neuritis*, or inflammation of the nerve. The paroxysms may be extremely variable, sometimes intermitting, at others remitting, occurring after regular or irregular intervals. A person who has once suffered from it is liable to its return, although he may have been completely restored. The malady is acute as regards the paroxysms, but so great a liability to their recurrence makes it generally considered a peculiarly chronic disease.

Neuralgia, then, is most liable to affect those nerves of the head, trunk, or extremities, *which are located superficially*, and hence are most exposed to vicissitudes, and such as are surrounded by bone or loose cellular tissues. Neuralgia may also affect the visceral nerves, as those of the heart, diaphragm, stomach, liver, spleen, bowels, uterus, kidneys, testicles, &c. And muscles, (like all other organs which receive mixed nerve filaments with motor nerves, that emanate from the cerebro-spinal axis,) *enjoy* in health, and *suffer* in disease, a sensibility *peculiar to muscle fibres*, if still in communication with the spine and brain by appropriate telegraphing nerves. This muscular hyperæsthesia, although less acute than that of the skin, is, however, susceptible, like the latter, of increase, of diminution, and of abolition.

M. Valleix was the first to point out the great fact, as regards *true* neuralgic affections, and which seemed to have escaped the notice of all previous medical observers and that was, that the *superficial nerve trunks*, and those that *emerge* from bony canals, are those most commonly affected; also, that there are certain other "*painful points*" in the course of a nerve which are more liable to be affected by this kind of pain than any other portion of the nerve. Dr. Valleix, by special research, thought he had demonstrated "*four several points*" on the course of a given nerve that are most likely to be the seat of neuralgia, or, rather, where the neuralgic pain is more liable to be manifested. According to him, the four marked points are as follows: —

1. "The *first point* where a nerve is apt to show pain, is *at the place where the nerve emerges* from the bony canal through which it passes: *the nerve is affected here*, and here it is tender to pressure; but the neuralgic suffering may be ascribed by the patient to this point, or elsewhere along the course of that nerve.

2. "The *second point is where the nerve trunk suddenly becomes more superficial*, or runs along near the integument.

3. "The *third point*, that is prone to show this pain, *is where*

*the nerve branches traverse the muscles* to reach and become ultimately distributed superficially in the skin and fascia.*

4. "The *fourth point is where the terminal nerve twigs are spread out to be lost in the integuments.*"

Now, it is important to notice that this most valuable information, although not perfect, puts us on the right track, and enables us to find, usually, the exact place, where the *tenderness from gentle pressure* indicates the nature of the affection, and the propriety of local applications.

We notice that Dr. Duchenne, of Bologne, as also M. Brown-Sequard, and others, are lately disposed to regard *neuralgia* as a veritable "*discrasia*," much like that in gout and rheumatism, which in one person determines to the *neurilemma*, more particularly along the larger nerve trunks, and so causing true neuralgic pains; while, in other persons, this *discrasia* has an *election* for the great toe and the condiles of the joints, and so producing that other class of very peculiar pains which characterize a fit of the gout; and yet still, in other persons this discrasia has rather an *affinity* for the ligaments of joints, *bursæ* of the tendons, and the *periosteum* of the bones, which characterizes the pains of rheumatism. That special condition of the body which gives rise to shifting pains which are sometimes seated in the muscles, (muscular hyperæsthesia,) at others about the joints, (neuralgic rheumatism,) at other times in the joints, (rheumatism,) &c., seems to favor this idea. It may be exactly true, or it may not, however, for as yet it is not further demonstrated. Dr. Alfred Smee, of England, and Dr. De la Rive, of France, are of the opinion that neuralgia arises from a *material* disturbance in the natural nervo-electric state of those nerves affected, or of the whole nervous system, where is shown the neuralgic diathesis; and that the disturbance is more usually at the *peripheric* nerve pole; but what that disturbance is, precisely, no one is able to define.

If we comprehend under this head all those very painful affections, wherever seated, which are apparently unconnected with

* The author defines this point, and some others, still more closely.

inflammation, and which are not the result of some important or discoverable lesion, we shall find a large class, that doubtless arise from the encroachments or compressions of blood vessels upon the nerve trunks, just as they pass together through bony canals. This distention of the blood vessels may arise either from an extraordinary flow of blood in the arteries, or from a faulty or *sluggish* return of blood through the veins; it may occur, then, where there is too much blood and too great a distention of the vessels from the quantity; *but more frequently* does it occur from the venous congestion, "stasis" or stagnation from atony, i. e., from impoverished blood, and *from deficient enervation* and want of tone in the tissues. Exposures to sudden cold, as well as traumatic causes, also produce it.

Since the commencement of the present century, neuralgia has been distinguished from rheumatism and gout. At first the study of this class of pains was limited to their occurrence in the face and lower extremities, and then the terms "*tic douloureux*" and "*sciatica*" were generally applied; but more recently the term "neuralgic affections" has been extended to all morbid exhalations of sensibility, or excruciating pains in parts not manifestly inflamed.

*Facial neuralgia*, or "*tic douloureux*," is an affection whose pathological and symptomatic phenomena can be stated only in connection with the morbid exaltation of sensibility of which it is constituted. The suffering is generally referred to one of the three branches of the *tri-facial* nerve, (the fifth pair,) and darts along the ramifications, so that the precise spot or tract can be indicated by the patient. But it occurs more frequently in the two upper branches than in the inferior maxillary branch. When seated in the *first* or *ophthalmic* branch, the frontal ramifications of it are oftener affected (brow-ague, or *clavus hystericus*) than the *lachrymal* or nasal; but, in some cases, it involves all these — there may be a superabundant secretion of tears, or pain in the eye. When the *second*, or superior maxillary branch, is the part involved, then the *infra-orbital* is the seat of suffering, and that more generally where the nerve passes out from that foramen; or the pain may radiate from there, or it may be expressed mainly in

the upper lip, or *ala* of the nose, or in the gum. If the posterior dental ramification of the second branch is the seat of the affection, then the attack resembles the most awful toothache. If the *tic* is in the third branch of the tri-facial, it is manifested in the inferior dental nerve; and more usually in the mental portion where it *emerges* from the mental foramen on the chin, and the pain extends to the inferior lip. It sometimes extends through the branch that communicates with the seventh pair, and thus implicates it. The pain may be seated rather in the *anterior auricular* branch, and then extends to the temple in the course of the temporal artery. The pain may extend to the lingual branch.

During the paroxysm of facial neuralgia, the muscles of the face are often contracted on the affected side. The least motion, noise, or light aggravates the pain; usually there is no febrile commotion in the system, and no acceleration of pulse, even during the most intense suffering. The duration of neuralgic pain may be but an instant, a minute, or an hour, or even longer. It may terminate as suddenly as its attack. It may be liable to recur regularly, or irregularly, for a very great length of time. It may cease for months, or years, completely, and then return, unasked, even more severely than before. The most trivial circumstance may be sufficient to *bid* it *up*, — such as vicissitudes of temperature, a moral emotion, or a sudden faulty function.

For *tic douloureux*, and other intense neuralgia, we may choose different methods of procedure in different cases, or even for the same case, where the previous treatments fail. For severe cases we must boldly adopt severe treatment. Plant a small metallic electrode, negative, on the face, over the exit of the nerve that is twingeing, or over the most painful spot, while the other large moist sponge electrode, positive, is already planted just back of the ear, on the same side; then let on the faradaic current, moderately at first, then more and more strongly, until full strength; all the while steadily retaining the metallic electrode, or a very small sponge electrode, over the painful spot. But there are several varieties. One is, where there are both pain and tenderness;

and this may be hyperæsthetic, and curable by faradaization, tonics, anodines, and aconite ointment; or it may be a neuralgic or a rheumatic inflammation or induration, and curable by electricity and covering with oiled silk; or it may be caused by a reflex, from sour or deranged stomach, decayed teeth, loaded bowels, or gravid uterus; or it may arise from some central organic mischief; and there are others that evidently arise from the aguish miasm. One class of all these has darting pains, which we term *tic douloureux;* while the other class has quite a tolerance of pressure, (and pains without darting,) which Romberg terms "*anæsthesia dolorosa.*" Electricity acts as a magic wand in most of these; but in others it fails.

OTALGIA, or earache, and ODONTALGIA, or toothache, frightfully painful as they are, may be, and very often are, simple neuralgic affections. But the toothache is more frequently referable to some source of irritation in one or more of the teeth, or on the antrum or gums. But often without these more obvious causes, and as often in connection with them, an attack of toothache is brought on by the very same causes, and in the same way, as those which produce other forms of neuralgia; the local source not being sufficient in itself to develop this morbid manifestation. If it is attended with inflammation, then electricity is not indicated. If there is ulceration, or caries, it is likewise useless, except perhaps for the temporary lull. But when the attack is in the gouty or rheumatic, and the affection is truly in the *antrum*, *nerve*, or *periosteum*, then an electric current can relieve like a charm; and that more uniformly, and for more permanency, than any other means I ever employed. The pain in the ear, that is characterized as neuralgic, appears to be seated in the *chorda tympani*, and perhaps also involving the acoustic nerve. It is often associated with a *face-ache*, or neuralgia of the face. The pain in the ear is unattended with inflammation, but is accompanied with noises in the ear, and sometimes with temporary deafness.

Neuralgia of the *cervical nerves* is perhaps quite as common; and cases do now and then occur from puncture of the nerve in bleeding from the jugular vein, or from leech bites. But a more moderate and remarkably persistent kind of neuralgic-

rheumatic affections of those nerves and their depending muscles is frequently observed. These are more chronic; in some cases and respects, more resembling rheumatism, while in others neuralgia; and are often attended either with contractions or spasms of some muscles, which may prove temporary or permanent. Beware of a *caries* of the upper cervical vertebræ. Take counsel of the *history* of the case.

Neuralgia of the *occipital nerve*, which may also be attended with stiffness of the muscles of the neck, is often a very painful and tedious affair. A very distressing case, of long standing, of this kind, sent me by Dr. D. H. Storer, has been greatly benefited by electro-puncture. I inserted two needles very deep on each side of the upper cervical vertebræ, so as to embrace in the current the long, posterior ganglia, or at least the roots of those seven or eight small branches of nerves that leave these ganglia near the posterior arch of the atlas, and which, it is well known, are distributed to the muscles of the upper and back part of the neck and head.

Neuralgia of the thoracic or *intercostal nerves* is often presented in both sexes, either amounting to true neuralgic acuteness, or hardly more than a rheumatic aching, (muscular hyperæsthesia,) or perhaps attended with passing spasms. They may arise from vascular congestion of a portion of the spinal cord, or of its membranes, or from actual inflammation or other morbid state in those parts; but this latter is not so positively agreed upon. Besides, there are very many painful cases that affect the thoracic and abdominal nerves, and their depending integument and muscles, without any corresponding evidence of irritation, congestion, or inflammation of the cord; while, on the other hand, evidence by post mortem actually shows these disorders of the spine, in other cases, which had been entirely unsuspected, by not being manifested by more painful expressions.

Thoracic neuralgia shows itself about the seventh, eighth, and ninth ribs, at the spot where they unite with their cartilages, and that mainly on the left side. This indeed constitutes the familiar "*infra mammary pain*," which the author has found is by no means peculiar to females, and hence is not neces-

sarily *hysterical*, even when it occurs in women; although it is equally true that very many of those cases do seem to be so characterized. The pain darts in the course of the nerve, sometimes to the spine, and embarrasses the respiration. It is occasionally attended with pain in the epigastrium, or bowels; and in women there is *hysterical colic*, or pains in the region of the ovaries or uterus. The pain may be diagnosticated from rheumatic by the former *showing great sensibility of skin*, and the latter showing soreness of the muscles, by pressure, or in using them. It occurs more usually in the *left side*, and but rarely in both sides at once, or in succession.

Intercostal neuralgia is a very frequent complaint. According to the careful researches of Dr. Valleix in this department of pathology, (or rather *abnormal physiology*,) he found these pains rarely in the first and tenth spaces, and in the eleventh and twelfth never. This kind of pain is increased on pressure, by full inspiration, or by cough, but not equally so along the whole course of the nerve. There are *points* where the pain is acute. These are, first, a little one side from the spinous processes, where the nerve passes from between the vertebræ; second, at the anterior portion of the intercostal space, and near to the epigastrium and sternum; third, about the middle or arch of the ribs. The pain may be dull, aching, or a mere sore feeling, and be persistent; or it may be sharp, darting, and often recurring. And here is the proper place to class and include all those cases usually denominated "pleurodynia." Intercostal neuralgia is often connected with the hysterical condition, and disordered digestion. It is also found to arise from over-work and from exposure. But probably the greater source is, *impaired nervous energy*, and at the same time *an irritation of some portion of the organic nerves.* Besides, as we have said, it may, or may not, be connected with, or arise from, a positive venous congestion of a corresponding portion of the cord, or rather of its investing membranes.

Such are the facts in regard to the cervical, thoracic, and abdominal branches of the cord; but if we pass down to the lumbar region, we often meet with pains here other than the true neuralgic. M. Chaussier describes life-like cases, that refer

the pains to the kidneys, ureters, bladder, or uterine organs. Sir Astley Cooper, however, in his work on the Testis, (p. 110,) gives some cases of *tic douloureux* of the spermatic cord. He believes the pain to be truly *seated in the nerves*, as the pains dart only along their route. He states that he carefully dissected all the testicles which he removed on account of this fearfully painful affection; but there was found no kind of structural change in any of them — proving that they were actually neuralgic. (See p. 466.)

Both the aggravating and alleviating agents and circumstances, lead us to see that "lumbago" is, after all, more nearly allied to neuralgia than to rheumatism, in respect to the character of the pains, and is referable, in a great majority of cases, to impeded venous circulation in that portion of the spinal cord that is below the origin of the *cauda equina* at the second lumbar vertebræ, and evidently now and then involving also the roots of those nerves that supply the lumbar muscles. If the anterior branch of the first lumbar nerve is involved, the pain extends from the loins and crest of the ilium to the groin, the spermatic cord, testicle, or scrotum, or to the labia of the vulva in the female. (See p. 460.)

Neuralgia of the upper extremities is more frequently found seated in that portion of the *cubital nerve* at the elbow, which passes between the internal tuberosity of the humerus and the olecranon, from which spot the pain darts down in the route of the nerve, even to the ring and little fingers. Sometimes the pain starts from the *brachial plexus* and shoots backwards through the *supra-scapular* nerve, but more frequently through the *sub-scapular* nerve; and still more frequently through the nerve *circumflex;* the pain then being seated in the back and lower portion of the deltoid, and near its insertion into the humerus. A most excellent and somewhat aged lady, who had suffered from this painful nerve for about two years, in spite of skilful care, was sent to me by Dr. J. B. S. Jackson, and was entirely cured of it by a dozen sittings for the primary current of galvanism, aided by electro-puncture. Some exceedingly painful and protracted cases of neuralgia of that branch of the *median* nerve that ramifies the dorsal aspect of the thumb, have

presented, showing the seat of intense pain mostly in the thumb, at its side, or about the root of the nail. (See p. 461, 1, 2, 3.)

Neuralgia, uncomplicated, of the lower extremities, is, perhaps, most frequently observed as most severe when it occurs in the *sciatic hollow*, between the great trochanter and the ischium. The pain is either fixed there, or shoots along the course of the great sciatic nerve, or shows itself at the femoro-popliteal nerve, extending, in one case, upwards to the sacrum, or, in another, and more frequently, downwards, even to the ankle and foot. Now, this whole family of sciatica was for a long time classed with rheumatism, until M. Chaussier and others demonstrated that there is here essentially a form of neuralgia, although at times the given case may show an alliance equally with inflammation or rheumatism; but these latter are by far the more rare. It was also formerly confounded with all kinds of painful affections of the hip region, whether inflammatory or rheumatic, primary or symptomatic — all were called *sciatica*. But true sciatica must be sifted out from these to be viewed and successfully treated, first as inflammatory, and then as neuralgic. In these the greatest suffering is sometimes in the anterior tibial branch that terminates at the great toe; but oftener still in the peroneal branch of the *external popliteal*, which is one of the continuations of the great sciatic nerve, and terminates on the outer side of the foot. The accession may be very sudden, but it is usually preceded by a painful prickling or a numbness along the thigh, or down outside the *fibula*. Only one limb is usually affected. The slightest cause may bring on anew the paroxysm of pain, as the warmth of bed, mental emotion or excitement, motion or exertion. The continuance is as tricky and uncertain as other neuralgia. Where it has been long standing and severe, there sets in a lameness, and some *dragging of the limb*, with a partial palsy and wasting of the muscles of the limb. There, then, may also be trembling of the limb or *formicans*.

Neuralgia of the *femoro-pretibial* occurs less frequently than sciatica. The *seat* of pains affects the great trunk of the *anterior crural nerve* as it passes out from under Poupart's ligament, or the crural arch at the groin, and before it so abruptly divides

into its many cutaneous and muscular branches. The pain then darts along to the middle of the inner thigh, or to the inside of the knee, or it may trace along the internal *saphenus* nerve, which is the main continuation of the anterior crural, down the inner side of the leg to the inner ankle. Those minute branches of this nerve that are distributed about the *lower edge of the patella* were the seat of most excruciating attacks of neuralgia for years, in a gentleman of eminence in Cambridge, whom the author cured more than a year ago by electro-magnetic currents. The morbid action in this case was first set up by hitting the knee against the steps of a railway car. In another case, a young lady fell up stairs, and struck the knee about two inches above the patella, which hurt her somewhat at the time, but it was soon forgotten. For several years past she has been more or less lame, and subject to paroxysms of most excruciating pain in a point just below that knee, which extended up to Poupart's ligament, and the anterior crest of the ilium. She is now entirely free from lameness, nor has she the least pain in the knee even after severe walks; but there is evidently a rheumatic diathesis, and she now and then feels the grumbling pains of it on vicissitudes of weather, but not at the knee. Both Galvanic and Faradaic currents were employed, and she received some nine sittings in all, with medical treatment.

True neuralgia of the muscles may be known from the rheumatic affection of the muscles, because in the former the pains are very much more acute, and recur in frequent paroxysms; but there is not the dull ache or numb sensation in the interval of neuralgia that there is often in a rheumatism of the muscles. *After the pain ceases, if it is neuralgia, there is great weakness, or even partial palsy, of the muscle.* It may often be suspected as attending some insidious organic disease of the cord, or brain, as it does sometimes; and apoplexy or paralysis may, sooner or later, attack the patient. So, indeed, do I always suspect even neuralgic pains *that are chronic, which proceed from the cervical or the brachial plexus*, the recurring paroxysms involving the shoulder or upper arm. And this may prove more *generally* true of all severe and long recurring neuralgias,

especially those of muscles; particularly if they do not completely yield to correct electric treatments, provided always the habits of the patient will not account for them. As we are led to be suspicious of insidious lesions of, or formations in, the brain, from the ugly muscular neuralgias of the shoulder, so should the severe neuralgic pains of the muscles of the loins or thighs always put us on our guard, at least by a suspicion of the existence of softening or other organic lesions of the cord, or its membranes.

Neuralgia of the *skin* (true hyperæsthesia of the sentient nerves) is frequently noticed in connection with some eruption, as *herpes;* also in most hysterical cases. The sensation is exquisite sensitiveness to every touch, or intense prickling, or insufferable burning, or true pains in the skin. This is often alternated with numbness, &c.

A neuralgic affection of the *periosteum* of the bones, I am seriously led to believe, is more frequent than recognized. When observed, there is too ready a disposition to attribute it to mercury or to syphilis. True, it is very often, in part at least, rheumatic; but it is equally true, that the periosteum of the skull, teeth, and of the shafts of bones do present true, uncomplicated neuralgic pains.

Neuralgia may attack the *ganglionic* nerves, and hence most visceral neuralgias, with but few exceptions, may be referred to this medium. We find presenting in practice cases that properly come under this caption, that manifest pains mostly in the head, and constitute one large class of the *neuralgic headaches.* These are the plunging and bewildering head-pains, that now and then a patient of delicate constitution or of high nervous endowment or temperament has to suffer in regular or irregular and often recurring paroxysms, for years together. The attacks are usually intermitting; but I have had some patients who suffered for many years, with remissions it is true, but never entirely free from the pain. Light, heat, cold, mental or moral emotions, and the state of the stomach aggravate it, and at any time provoke to a paroxysm, the same as in any simple and true neuralgia. Is it, then, *an excessive exaltation of sensibility in the ganglionic*

or sympathetic nerves, or is it owing to *increased vascular determination to the head*, — or *owing to vascular turgescence from sluggish circulation* in the head? I am more inclined to believe it is *both* the former and the latter. In a word, I believe there is a class of ganglionic neuralgias. (See p. 469.)

In like manner, and for the same reasons, we may find cases presenting of neuralgia of the *heart*, as *angina pectoris*, and other forms of nervous heart-pains; neuralgia of the *stomach*, as gastralgia, or gastrodynia, and perhaps complicated with other morbid conditions; neuralgia even of the *liver*, called hepatalgia; of the *spleen*, and called by systematic writers *splenalgia;* neuralgia of the *duodenum*, *colon*, and *ileus*, called *nervous colic*, and more particularly *lead colic;* neuralgia of the *kidneys*, and of the *urinary bladder*, called *nephralgia*, &c. A neuralgic affection of the urinary organs is usually attended with *increased* secretion of urine, as, indeed, augmented secretion is characteristic of neuralgia of all secreting organs.

*Neuralgia of the uterus* is a fact; but these cases are more generally turned over to us as unmanageable cases of *uterine congestion*, or of *irritable uterus*. The cauterizing the cervix, the pessory support, the leeches, douches, and injections, fail to relieve or restore, but rather aggravate these cases, because they are in effect true irritants to this condition of the organ. Therefore, from among all the painful affections of the uterus, we must be careful to discriminate those that are truly and simply *neuralgic*. Now and then we find distressing cases of true neuralgia of the *vagina*. The patient more generally describes it as a most acute burning or scalding, or as a heavy plunging pain, occurring *often*, but not lasting long, and followed with a continued aching, throbbing, or soreness. There is usually found no lesion of the vulva, vagina, nor of the uterus. But we should recollect always, that this neuralgia may be, as it sometimes is, merely symptomatic of serious organic lesion of the womb.

*Visceral neuralgia*, being an affection of the *sympathetic system of nerves*, may therefore constitute the most severe and protracted bodily sufferings under which mortals can so long live. The source of sufferings, undefined, yet everlastingly com-

plained of, by the *hypochondriacal* and the *hysterical*, is doubtless seated here. Their case is very generally viewed either as mostly imagined, or else as remarkably exaggerated. This view of their case is taken, all the more, because their general health appears so good, or rather because it is so little impaired. But these, to them, abnormal sensations and indescribable sufferings, engaging the entire life attention of the patient, develop a persistent despondency or peculiarity, with a ceaseless apprehension. But to other persons, these complaints being viewed usually in the light or connection of very slight evidence or appearance of real ailment, often lead to a sincere belief in their want of reality; while, in fact, *they should be viewed*, as all needful evidence of a greatly impaired balance of action, in the great chain of ganglionic nerves. Dr. Copeland thinks it is a state of *asthenia* of this part of the nervous system, and that associated with a morbid exaltation (hyperæsthesia) of its physiological sensibility, which makes it a true neuralgia, and not unfrequently attended with some hidden functional or structural lesion of one or more important internal organ, and more particularly of the organs subservient to the perpetuation of organic life.

*Infra-mammary Pain.* — Dr. Coote, of London, says he has closely analyzed a series of some fifty cases of infra-mammary pain, and now finds it necessary to distinguish between *two kinds* of painful affections, to which the infra-mammary region is liable. The *first class*, he thinks, should be designated as "intercostal neuralgia," for it is liable to affect any region of the thoracic walls. The character of this pain is acute, plunging, paroxysmal. It is seated in one or more intercostal spaces, and mostly where the *cutaneous* branches of the nerves are most freely distributed, sometimes shooting around the chest, as if above the course of the nerve and its ramifications. Here there is superficial tenderness, or tenderness on pressure, or there is periodical pain. (See p. 469.)

The *second class* of infra-mammary pain that Dr. Coote wishes to call our attention more particularly to, is a dull, aching pain, that is *seated*, being situated in one definite locality under the left breast, and extending generally over the seventh, eighth, and

ninth ribs, with the seventh and eighth intercostal spaces; never shooting along the nerve course, but rather darting deeply back *through* the chest to the back, or into the throat, in the former case seeming to give rise to the *inter-scapular pain;* in the latter, being associated with the hysterical globus. It is rarely tender on pressure, and it is not regularly periodical. He says, that uterine disorder does frequently accompany the true infra-mammary pain; but that it should be the cause of it, is impossible, for these two conditions cannot stand in relation to each other as cause and effect, as either does exist without the other. The infra-mammary pain is thought by some to be one of the most common symptoms of "incipient lateral curvature of the spine," and should always lead us to investigate the state of the spine, whenever we hear of this *ceaseless* though variable pain. But this, to my mind, has been exaggerated as to *frequency* of occurrence. These being facts, and for other weighty reasons, Dr. Coote infers that true infra-mammary pain is a mere *symptom* of a generally depressed or diminished state of the nervous endurance; and, secondly, that it is *one of a group* of symptoms intimately connected with the deranged vaso-motory system, and therefore with some vascular derangement.

The conclusions finally are, that true infra-mammary pain is simply a species of *peripheral neuralgia*, having, probably, its origin in mal-nutrition of the smaller nerves and blood vessels. The immediate cause of this kind of vascular derangement consists in disordered enervation of the smaller arteries of the whole body, occasioning irregular spasms and dilatation of their walls — a condition, which, while in the infra-mammary region it occasions neuralgia, in other parts gives rise to chills and flushes, to palpitation, to excessive or to defective secretion, to congestions, to hemorrhages, and to fluxes; while an analogous state of the nerves of the alimentary canal produces obstinate constipation. The cause of this extensively disordered state of the vaso-motory nerves is to be sought for in the more *general* conditions and habits of the patient. For obvious reasons, it is more likely to occur in women than in men, yet it does certainly also occur in men, as we often see.

If these views are correct, the indications for treatment are twofold. First, to arouse the vaso-motory nerves into at least temporary activity, so as to relieve special symptoms. Secondly, to give these permanent vigor, by improving the general innervation and nutrition of the whole body, and particularly of its surface. To this end employ electricity, food, air, and rest; to these the various tonic medicines are mere auxiliaries. Prescribe *formulæ* 1, 10, 12, or 5 and 34.

Young women frequently suffer from *pains* about the mammary region, and the intercostal spaces. These respectively are very often mistaken for *pleuritis*, or something else besides what they truly are, because these very different pains, occurring in the same place, are not studied and distinguished. But if you seek access to the dorsal or cervical region, and press *gently* along the sides of the spinous processes of the vertebræ, but not on them, or else along the lower margin of the ribs, i. e., tracing the fingers along between the ribs, from the spine forwards, you will very quickly *awaken* the pain of neuralgia, which may be at the point of pressure, or it may be awakened at some little distance from it, but in the course of the nerve, or in its peripheric branches. If the peripheric branches that terminate in the integument are thus aroused, it is still *neuralgia;* but if the deeper terminal (motor) nerve branches, that are lost in the muscle fibres, are the seat of the pain, and are aroused not so, but rather by touching the surface any where over it, then we have *muscular hyperæsthesia,* which after all is probably only a neuralgia of the terminal twigs of true motor nerves. This will prove quite a sufficient test to satisfy that you have there either found one of Valleix's *painful spots*, and the pain is a fair neuralgia, or else is that other nerve manifestation that we call muscular hyperæsthesia, (and has been called also muscular rheumatism, or neuralgic rheumatism of the muscles,) but not a pain proceeding from an inflammatory action, (except it be about the nerves,) but certainly not in the pleura, nor in the viscera of the thorax.

*Spinal Irritation.* — The views of Dr. Inman, of the Liverpool Royal Infirmary, should certainly receive our careful considera-

tion. He says the prevailing cause of these painful affections, termed "spinal irritation," in his judgment, is due to some morbid condition of the back muscles, rather than of the spinal nerves; and that the so-called "*spinal disorder*" originates more commonly in a feeble and painful affection of the muscles of the back. He says he has seen numerous cases in which these affections have been mistaken for symptoms of inflammation, and were treated by depletory measures, and rendered worse in consequence; in which Faradaizing, with a due amount of rest to the over-worked or strained muscles, with good diet, and other recuperating means, effected a speedy cure.

Passing from the painful affections of the muscles in general to those of the "spine" in particular, Dr. Inman considers that most of the cases of so-called spinal irritation are, after all, really owing to causes *originating* in the muscles, and that they ought to be treated generally by sustaining the general health, giving repose to the affected muscles, and assisting their action, when necessary, by quick and smart electric currents, by well-contrived artificial supports. The use of stays, therefore, *if not laced*, is not to be condemned as an article of female dress; *but when so used they are rather beneficial, by aiding the action of the muscles in preserving the equilibrium of the spinal column.* The reference of such cases to the general phenomena of hysteria is entirely unphilosophical. The views of Dr. Inman on the nature of *spinal* irritation, when summed up, are these: —

"I believe that the vast majority of the symptoms considered as the *result* of spinal irritation arises rather from over-exertion of one or more portions of the muscular system in the already debilitated subject; that the spinal tenderness of the spinous processes has a similar origin; and that the other symptoms considered as *resulting* from spinal tenderness are concomitants only, and are referable to the common cause."

*Local Pulsation*, occasionally noticed in the male, but far more frequently in the female, may be put down as "*local hysteria*," and arising from that peculiar state of the nervous system when hysteria may be manifested. This is a strong pulsation of the aorta in the epigastric region, *strongly simulating*

*aneurism.* But by observing the decidedly nervous, hypochondriacal, or hysterical state of the patient, we need feel no apprehension. As the nerves become toned, and the strength is improved, these symptoms will vanish. Hysterical spasmodic affections there are, among which are a curious class of maladies which often prove exceedingly troublesome, as aphonia, and croupy laryngeal affections, and likewise sobbing and sneezing.

Case. — Cornelia B., aged eighteen, came under treatment, complaining of severe pain in the dorsal region. She was a fleshy and stout-built girl, but looking in some sense delicate and unhealthy. Her business was that of a seamstress, and of late years she had run a stitching machine, in the employ of Hovey & Co. She reported that her pain and extreme weakness had existed for the last year previous, so as to quite disable her for work at times; particularly did this occur just before her catamenial periods; the pain occupying the middle of the back, and along the region of the spine, which was so extremely tender to the slightest touch or pressure, that any application of the hand to that portion of the back, even over the dress, would cause most disagreeable sensations, and if applied directly to the skin, bring on a turn of great suffering. When more closely examined, I found that this pain was confined to the fifth, sixth, seventh, and eighth dorsal vertebræ; for while on any other portion of the spine she would bear even forcible pressure, the least touch here caused her to scream with pain, so extreme was the sensitiveness of this portion of the back. But mark — if her attention was suddenly and strongly drawn off to some other distant object or subject, I could carefully and adroitly glide my hand from a sound region to this exquisitely tender region, and handle it roughly for that time without producing more effect there than elsewhere. This fairly diagnosticated the case as what is called *local hysteria* in the more common acceptation of that term.

Her treatment may be summed up thus: To have one *seance* daily, and at the same time to continue the medicine that she had been taking from her family physician, viz., *Griffith's myrrh*

*mixture*, with ammonia and valerian added, (which, by the way, is one of our very best preparations of iron for these cases.) The first few sittings occupied only three minutes each. *Circle treatment* was the principal method of operating, and this was done by placing one large and moist sponge electrode, which was the *positive*, over the painful part, while the other electrode was applied some ten inches from the first, and carried in a radius about it, but *without* removing either of them until through; using at first a very gentle and then a stronger Faradaic current, but if at hand, a galvanic current is better still. This was continued for one week. Said she was certainly one half better. To omit medicine and electric treatment now for one week; but to take in the mean time, twice a day, a pill of the sulphate of iron and quinine, and to apply to the dorsal spine a lotion of soap liniment and extract of opium, in equal parts, at bed time. Improvement continues; looks much better, and her gait is more natural and free. To repeat the electrical sittings and the myrrh mixture daily for a week more. The negative electrode was often carried as far as the cervical spine, the pit of the stomach, and over the bowels, the pelvis, lumbar and sacral regions. This quite chased away all pains; her appetite and rest are greatly improved. This case was dismissed with advice to shock the dorsal spine every evening with a towel squeezed out in very cold water, and applied suddenly, with a wipe up and down the whole back, which was then to be as quickly rubbed and dried, and the patient to be got into bed, well tucked in. She immediately resumed her former employment, and has regained very substantial health.

### *Headaches.*

When tracing the cause of headaches, what do we learn from anatomical considerations, as to the probable *source* of pain *within* the cranium when a person is the subject of a true and profound headache? The *source* of distress, says Dr. Symonds, does not appear to be in the nervous matter, vesicular or tubular, either in that of the cerebral hemispheres

or of the cerebellum. No evidence of *feeling* has ever been obtained by vivi-sectors, till they approach the sensory ganglia — the *thalami optici* and the *corpora quadrigemina*. But these, on the contrary, *are the centres of sensation* to all parts of the body, as well as to the head. All analogy points to some certain nerves as the source or medium of the pain. Numerous as are the nerves that come out of the cranium, there are to ocular view but very few that go into it. A branch of the *sub-occipital* accompanies the vertebral artery; but a *large majority* of the other nerves, destined for intra-cranial purposes, are derived from the *sympathetic*. *These*, then, we may feel satisfied, *are the nerves* which are of the chiefest interest to our present inquiry. Nerves of this class, we know, accompany blood vessels; and when we observe the large amount of these vessels, — as the brain and its membranes are more liberally supplied with blood than any other organ, the quantity being computed as one fifth of the blood of the whole body, — we might here, without searching farther, realize the enormous amount of minute network of ganglionic nerves. By the microscopic examinations of modern anatomists, in fact, they are traced in the greatest abundance.

There is also found a vast interlacement of nerves at the base of the brain, derived from the plexuses of the vertebral, the basilar, and the carotid arteries, mingled with nerve threads connecting with the third, fourth, fifth, and the sixth pairs of cranial nerves, besides branches in the cavernous plexus, derived from some of the upper cervical nerves, as well as those connected with the pituitary body, otherwise called the *cephalic ganglion*. Now the nerves proceeding from this network, and accompanying the arteries of the brain, must possess the mixed endowment of their several sources. But then, whether or not the sensory properties of ganglionic, otherwise called sympathetic nerves, are entirely dependent on the cerebro-spinal fibres contained in them, (as Valentin believes,) or whether they arise from the gray fibres which *become* sensitive when altered by disease, (as Volkman believes,) is still a question. It is enough for us to know that the compound nerves of this

sort seem to be capable of fulfilling almost every conceivable function of a nerve.

Whatever these peculiar nerves may effect on the chemical processes of the molecular laboratory of ultimate tissue, — whatever regulation they give to the blood vessels, — it can scarcely be doubted, says Dr. Symonds, that in many parts of the body they actually send messages of pain, if not of pleasure, to the sensorium; and that *they* are the telegraph lines that transmit influences from the seat of *emotion* to the parts where they are distributed, and perhaps have a reflex function also. They only seem not to attempt to convey motor impulses from the will. That our general sense of well-being must derive its favorable tidings from the various viscera, through these "union" telegraphers, can hardly be doubted; and certainly there is no other channel through which flow the miseries and anguish of the very many visceral disorders.

Seeing, then, that the ganglionic (sympathetic) nerves, so abundantly distributed through the brain and its membranes, *are largely implicated in profound headaches*, our next inquiry is turned to find the agencies which so act upon or through them as to cause painful feelings. Some of these are, obviously, local changes in the cerebral structure, as from sluggish circulation, injuries, inflammation, or organic disease. There are also changes in the blood itself; and there are also disordered states of the nerves themselves, resulting often from functional causes, as in prolonged or excessive mental exertion, emotional excitement, &c. Other causes there are that act by sympathy, as through the nerves of special sensation; for instance, vivid light, or loud noises. There are also very familiar examples of *head pains* from impressions made on the branches of the fifth pair, as well as on the gastric, and on the intestinal, or genital nerves. Now, the stomach and the liver are always blamed for these profound headaches, and doubtless they are often guilty; but I believe that a too great, or otherwise bad impression made *at any one point*, — as on the eye, in the head, or stomach, — will involve the whole in a paroxysm of derangement and pain. If this is made in the brain, the

stomach will as certainly be deranged, and the tongue foul, the bowels will tardily throw off scybalæ with mucus, etc., as if *vice versa*. This is a case of *hyperæsthesia of the ganglionic nerves*, and more particularly of that portion within the cranium.

Headaches and pains in the head, then, may have either a diffused peripheral site on the scalp, as in persons of high neurotic temperament, or the pains may follow the course of the supra-orbital nerve, or the temporal branches of the *portio dura*, or the branches of the sub-occipital, and it will show its character either as hemicranial, or as "*clavus hystericus*," or as simple *neuralgia;* or the pain may have a *periosteal* seat, as in the rheumatic, or syphilitic; while here we are examining, as I believe, true *inter*-cranial headaches, arising possibly from molecular alteration of the nerve substance of the brain. But I am most strongly inclined to consider the elaborate compound network of intercranial *vascular* and *nerve filaments* (of the sympathetic) to be in almost, if not all, *profound headaches*, the very focus and medium of communication to the sensorium. These are ganglionic nerves, as we have just shown, and attend every capillary and fringe of minute ultimate artery.

Now, we know that periods, and *habits of successions* of various sorts are the very nature of our nerves. They respond to, and learn to call for, habits — good regular habits; so will they soon learn to repeat, and even *demand*, evil habits, and painful periods, *as if natural*. Indeed, *the periodic evolution of nerve force is a law of our very nature;* and as this is true in physiology, so do we often see its force in neurological pathology, (morbid physiology?)

Each new case of serious headache we examine, the first questions we should ask our own judgment are, where is the *cause?* and where the *seat* of the pain? — whether the head-pain really *originates* in the cranium? If the case is obdurate, we naturally query whether it may be owing to supra-orbital neuralgia, or to rheumatism of the scalp; to periostitis, or disease of the bones; to ear affection, to syphilitic affection, to

*threatening* brain disease, inflammation, fever, or else to some morbid or deranged condition of the stomach, liver, or bowels, or of the vaso-motor nerves. To discover and understand well the case of a real *intra-cranial headache*, requires skill, and a full knowledge of the minute history of the case, even in all its particulars and coincidents — a scanning of the symptoms and circumstances attending the head-pain, more than the character of the pain itself.

A *nervous* or neuralgic headache affects both men and women, but more frequently the latter; and more particularly those who are neurotic or anæmic. It is a *violently* sharp remitting or unremitting headache of short duration, although it may, and generally does, return from time to time. It is not attended with fever, and there is no disturbance of the brain, excepting now and then some confusion of vision and thought; but when it is over, there is great lassitude, and much real exhaustion.

As aid to the predisposing cause, any thing whatever, external or internal, that agitates or frets the nervous system, may be the producer of these attacks. So, also, a strong pleasant mental impression, as the sudden appearance of unexpected friends, or the arrival of joyous news, or an accident or circumstance that fully engages the patient's attention, may, for the time, as suddenly cure it.

*Rush of Blood to the Head — Hyperæmia of the Brain.* — A true brain hyperæmia, according to the rules of diagnosis by Da Costa, is to be recognized as either physiological or pathological. It is not to be confounded with the more common *venous* congestion, where the effect upon the brain is more like anæmia than true hyperæmia. Pure cerebral hyperæmia requires for its production two conditions, viz., an increased action of the heart, and a relaxation of the contractile coats of the cerebral arteries, great and small. There are various conditions that cause paresis of the vaso-motor nerves of the cerebral arteries, which give rise to this state. For instance, we see persons who flush very greatly in the face after a hearty meal, the cause being in the

nerves of the stomach. Some young persons, and some highly-sensitive ladies, suffer exceedingly in this way. In these cases there is, probably, too great, or some, morbid impression conveyed by the sympathetic nerves of the stomach to their ganglia, and thence to the vaso-motor nerves of the cerebral arteries; and thus the rush of blood ensues. Some of these cases are, no doubt, the result of an hereditary, or some other, *primary state of paresis of the cerebral arteries;* but in none of them does the history or symptoms point to any sort of primary mischief in the brain itself. Simply a moderate and strict farinaceous diet, long pursued, I find best suited, as a necessary condition, to the cure of this class by whatever means we may pursue.

Another and more frequent cause, which is but secondary and functional, that predisposes to this "*rush of blood to the head*," is repeated moderate stimulation of certain kinds, which acts more directly on the encephalon, and excites it to increased susceptibility of functional activity *under slight causes* — such as a daily or frequent use of some kind of alcoholic liquor, or very small doses of opium or camphor. So will heat, malaria, and certain embarrassing mental emotions and excitations bring it on.

The hyperæsthetic headache may be, and to my mind is, more of the nature of a vaso-motor weakness; a diminished tone in the vaso-motor nerves of the blood-vessels of the tunics, or brain itself, or of all the head, and thus too much blood is allowed to pass through or linger in these tissues, rendering them too sensitive and painful. Dr. Abercrombie took this view, and says these cases may be recognized by the fact that "such a patient usually cannot bear a warm room, the noise of company, or even the exertion of cheerful conversation, without becoming distressed, and the headache increased; and the same effects are produced by bodily exertion. The patient seeks quietness, coolness, and darkness; and in these respects the disease differs remarkably from dyspeptic headache, which is commonly dissipated by exercise and cheerful company. Sometimes the paroxysm of this headache is accompanied by vomiting, and

sometimes *by violent throbbing in the head*" — which is true to the life. The pain in some cases is lancinating and acute; in others more obtuse; and it is usually worse in some particular spot, as the crown of the head or the occiput, or it may be very generally over the head. In some violent paroxysms the pain is intense, obliging the patient to remain for a considerable time in one position, the slightest motion aggravating it to perfect torture; and yet the remissions from this severe suffering are sometimes so remarkable as to lead a superficial observer into the belief that it is merely periodical headache, or connected with dyspepsia. The diagnosis is thus somewhat difficult, without the closest investigation. To *tone* the vaso-motor nerves is the cure of these cases.

*Cerebral hyperæmia* is, then, either attended with little or no discomfort, or else with the extremest distress; and this seems to be exactly in accordance with the temperament, and the existing condition of the nervous centres. When these are highly sensitive and excitable, the suffering is truly great; and this constitutes a class of the most intractable *headaches* that we may be called to alleviate. (See sub-chapter on sympathetic headaches.) Even in apparently healthy individuals, or persons of plethoric habit, this kind or degree of fluctuating *rush of blood to the head*, from an unbalanced condition of the upper and lower ganglia of nerves, may occasion not only pain, but even transient delirium, together with various signs of encephalic disturbance, such as extreme sensibility to light and sound; extreme excitability in certain respects, or in regard to certain things; restlessness, great forebodings, or intense gloominess, pain in the head, and visual hallucinations. There often is a flood of distorted ideas, like a grotesque or fairy panorama, flowing through the mind, and perhaps, in some instances, temporarily overwhelming it. Bewilderment and incoherence may follow; and then the patient is, to all intents and purposes, insane for the time being. If this should continue long, the next condition would be actual cerebral inflammation.

In his excellent work "*The Stomach in its Morbid Condition*,"

Dr. L. Parker relates the case of a person who, having recovered from slight hemiplegia of the right side, continued to have pain and throbbing in the head, thirst, flushing of the face, and occasional numbness in the limbs. The head was continually hot, the cervix was the site of severe pain, with occasional violent and sudden darting pains through it, which made the patient scream out; the carotids and temporal arteries throbbed violently, and the pulsations were seldom less than one hundred per minute. The epigastrium was the seat of a violent beating, was full and hot, exceedingly tender on pressure, and the seat of internal pains shooting into the hypochondria, where there was also fixed uneasiness. The stomach and intestines had become so morbidly sensitive that every thing taken produced pain, distress, and occasionally vomiting; and there was constantly, with the thirst, an intensely acid taste in the mouth.

The patient had formerly been medicated, and then advised good generous diet with stimulants; but was now treated by a few leeches to the epigastrium, and a nightly mercurial aperient, for a time, and then less and less frequently, the diet being farinaceous, small in quantity, at regular periods, and *no stimulants*. The cure was ultimately perfect.

The recovery of such a case would be more sure and speedy, even while pursuing the same treatment, if it were aided by a primary current of twenty or thirty elements, or by the extra current, or else by the faradaic, if steadily run for ten or fifteen minutes on alternate days, from the upper cervical ganglia downwards to the pit of the stomach, and over the *solar plexus*. It would be good practice, also, to faradaize the surface of the limbs on the alternate days. This, together with strictly enjoined rest for both head and stomach, and by a radical change of habit, will permanently cure from suffering and speedy ruin many such otherwise wretched persons.

*Hemicrania, or Megrim.* — This affection is usually neuralgic; an affection of the small cerebral nerves. It may also occur from a *tetanic state* of the muscular coats of blood-vessels of the "*regio cilio-spinalis.*" When it arises from this source the pupil

of the eye will be enlarged during the paroxysm. This form of megrim depends on some implication of the cervical portion of the sympathetic. Dr. Dubois-Reymond was subject for many years to this form of head-pain; and in a report of himself he says, that ever since he was some twenty years of age, although otherwise in good health, he has suffered every three or four weeks — after any little irregularity, such as fasting, over-wearying company, &c. — from general indisposition and slight pain in the right temporal region on awaking the next morning. This would extend, and increase in degree, until midday, and then gradually depart towards evening.

While at rest, the pain is bearable; but on the least movement it increases fearfully, as also from coughing, stooping, or any thing that increases the amount of blood in the vessels about the head. The temporal artery of that side gives a tense, hard pulse, while on the other side it is soft and natural. The countenance is wan and pale, and the *right* eye is small and reddish. When the paroxysm is at its height there is nausea, but never actual vomiting. As the attack is about terminating in the evening, the *right* ear reddens and becomes warmer, both subjectively and objectively. Sleep shortens the attack; but the *right* side of the hairy scalp often remains tender and painful for some time after. The redness and warmth that occur as the attack is going off, arise from the weariness and relaxation of the unstriped muscles of the blood-vessels, from their prolonged over-contraction. For this, faradaize the pit of the stomach and over the abdomen and thorax to thoroughly arouse the solar plexus, by a very smart current. Repetitions of this will not only relieve, but cure.

*Symptomatic headache* is a nervous headache, and occurs mainly in connection with chronic disorders (sometimes with temporary derangements) of other organs, as the liver, stomach, bowels, kidneys, or the ovaries and uterus. This sort of headache is prone to come on early in the morning — the patient awaking with the pain, which gradually increases through the day; and in some rare cases this is so uniform that it becomes

almost an historic fact with the individual. Among this class are those whose head-pains synchronize with a very peculiar state of the bowels, which are habitually irritable and morbid; yet there is neither constipation nor true diarrhœa, but rather a combination of both. Usually such patients have to hurry to the water-closet betimes, especially on rising from bed in the morning, to relieve the urgency of call, which in some is yeasty, in others balls of fæces with a jelly-like slime. The more this morbid action of the bowels, and distress, the more the head will ache. Neither physic, injections, laxatives, tonics, nor astringents have any sort of curative effect for these cases. Yet we must cure, or relieve the bowels, to stop the headache. (See chapter on nervous bowel affections.) There are others of these cases, among females, which are as evidently connected with an irritable, congested, or morbid state of the ovaries or uterus. To cure such a headache, these faulty functions must first be set right.

A profound intra-cranial headache may be the result of organic disease of the kidneys; which, leaving excess of urea in the blood, produces constant headache. *Very slow* lead-poisoning, a too long use of opium, quinine, strychnia, or other accidental poisoning, is often followed by pain in the head. A *continuous* head-pain, or ceaseless uneasiness in the head, is a rarely absent symptom of insidious *disease of the brain.* Such symptoms are ominous.

*Sick-headache*, which nowadays is called *bilious-headache*, has its origin, not in an habitual or constant derangement, but in the accidental, occasional, or periodical derangement of the stomach, liver, or duodenum. A cathartic, or an emetic, is the most speedy remedy; a well-regulated diet, aided now and then by an alterative tonic or laxative, is the best preventive and cure.

*Syphilitic-headache.* — *Encephalic syphilitis* comprises all those lesions of the meninges and encephalon that come under the topic of *alteration* of the texture of the head; such as tumors, vegetations, effusions, and alteration of structure in the brain, as softening, &c. The prominent symptom is *headache;*

which is of very frequent occurrence where such disease exists. This kind of headache is in degree usually severe, which tends to increase towards evening, to become very violent *during the night*, to diminish in the morning, and to continue more slightly during the day. Thus it is, in character, a remitting kind of headache. This nocturnal exacerbation should lead the physician to suspect the probability of a syphilitic complication or origin. In some very rare cases, we know, this headache is severest in the daytime; but they are exceptions.

There is likely to be the *insomnia* that so often characterizes the invasion of cerebral irritation, but which may be a sleeplessness independent of pruritis, osteocopic, rheumatic, or other pains, which so very often accompany this affection.

The general nervous symptoms to be looked for, if this is the state of the brain, are, an alteration of intelligence, of sensibility, (formicans, &c.,) and of mobility, as palsy or convulsions.

*The diagnosis* of this grave disease, (*encephalic syphilitis*,) from analogous affections, and for correct treatment, must be based upon the antecedents of the patient. The local symptoms, by their coexistence with the nervous accident, that suffice to reveal the syphilitic nature of the brain disturbance, are gummy tumors, or periostitis, exostosis, caries; necrosis of the face or cranium which is likely to injure the *os frontis*, bones of the nose, or the ethmoid; profound organic lesions showing the type of progressive palsy; and, if there is chorea, we should bear in mind that it usually appears otherwise only in the young. The *prognosis* must usually be formidable, at least unfavorable; but that will depend upon how early the thorough and prolonged anti-syphilitic treatment was employed; for if it be late, death is usually the only sequel. Timely, well-directed, specific, and constitutional treatment, alternated with the use of galvanism, opiates, and tonics, for lulling pains, and for sustaining and increasing the vital forces, renders the most of these cases easily curable; but with others, particularly if long neglected, the most energetic and best-directed medication too often proves unavailing.

Headache! — for years, perhaps, a profound and often-recurring distress *in* the very dome of the great nerve centre, where all the influences and sympathies of the entire organism and being conspire to awake it anew, and perpetuate its existence! How shall we cure it?

Now, my answer to all this is, first, simply, that *there is no one remedy — there can be no "specific"* for these cases. My rule of action here is, to stop the pain as soon as possible, and then prevent the recurrence by any and every possible means. Find out what causes the headache, and with greatest vigilance *avoid* this source. When the attack actually comes on, even unasked, then cut it short by any means at hand; *but cut it short*, break up the habit, break up any regular recurrence of paroxysm. One patient will find relief in standing up, another in lying down flat upon the back, another from opiates, but others only from stimulants; others get marked relief from a cup of hot tea or coffee, or perhaps these combined with morphia, or camphor, or brandy; while others find it better from a cold drink of boneset, (thoroughwort — *eupatorium perfoliatum;*) others there are who get relief from eating something, while a greater number are relieved by vomiting. But a sudden and *new mental diversion* will more surely *relieve it* than all the foregoing; and electric currents, applied according to the rules to be observed in other hyperæsthesia, will relieve *obstinate headaches* more uniformly, and that with a *curative tendency*, than all other known means together; but to this end the case needs to be studied, and the treatment must necessarily be more or less continued.

*Treatment.* — As a general rule, all cases — each individual case of head affection — must be carefully discriminated as belonging either to the class of *sthenic*, or asthenic diseases; and is to be treated accordingly. If with inflammation, or fever, or otherwise *sthenic*, then in proportion to the urgency of the symptoms, and the endurance of the patient, the antiphlogistic remedies, mild or heroic, must promptly open the treatment. Where the pulse is hard, and over 120 in a minute, the case will bear depletion, local or general, or both, with purgatives, antimony

or veratrum, and the application of cold. Then just as soon as mercury can be given, and carried to slight specific effect, the pain and the immediate danger will be gone; and the cure will be confirmed by rest and tonics.

But we must be reminded that head-pains, vertigo, disagreeable sensations in the head, and even sub-acute inflammatory headaches, are more often found depending upon an entirely different state of the brain. Here the opposite, the *asthenic*, treatment is required. The fact is, most cases of *chronic* headaches are cured only by the stimulus of good food, in moderate quantities and at regular intervals, with tea, aided by quinine, iron, and strychnia in minute doses, together with the occasional application of electricity over and through the vital organs, and the upper and larger ganglia.

The stomach must be kept sweet, and the bowels moderately free. When the case has been of long standing, if the pulse is feeble, and the patient is not made worse by food or stimulants, we may know that electricity and the asthenic treatment generally are clearly indicated; and that by such means the patient can probably be restored to health.

In all cases of severe headaches, then, excepting only those of inflammation, fever, or organic disease, the correct application of electricity is usually an heroic remedy, and is to be tried as aid for the cure. For definite methods of treatment by electricity, see Rules 6, 7, 8, pp. 464–5. Adjust the negative, large, sponge electrode, or the long-handle *swivel electrode*, down under the clothing, over the pit of the stomach, or a little lower, and there let it rest. Then the other large sponge electrode, positive, is to be carefully applied, and held at first just at the base of the occiput, over the upper cervical ganglia. Then gradually let on the current of *primary*, or *extra*, or faradaic electricity, and increase its strength to more than medium.

If primary, use thirty or forty cups. If secondary, increase it until the patient is well aware of it; but do not interrupt it, nor reverse it. Thus let it run in a downward direction for five minutes. Then begin to move the positive sponge, without once lifting it from the skin, gliding it down and up the spine, over

the sides of the neck, back, and front of the ears to the temples, and over the most painful side of the head for five minutes more, continuously. If the patient is faintish, give a recess. If head-swimming ensues, use less current; but if not, continue it a little longer, and, at the same time, work the positive electrode downwards along the back and sides, or else along the sides of the neck over the shoulder and pectoral muscles, so as to quit with the electrodes near each other. When about to cease the application, and finish the seance, do not stop the machine first, but gently glide off the negative electrode, and let the patient sit quietly with the eyes closed for a few minutes more before rising to walk.

In treating inveterate headaches, I more usually employ the primary current of galvanism than the secondary current of electro-magnetism, although this latter can, for it does, succeed in very many cases. But I must here confess there is no small difficulty in giving directions how to decide, in a given case, without trial, as to which of these currents is best adapted to be successful. Moreover, I here recognize the *law*, that must be observed in the treatment of all painful nervous affections, and that is, that a larger class is benefited by the *direct* current, while a smaller class is only reached with a truly remedial effect by the *inverse* current.

Therefore, generally speaking, the fair, the fleshy, and the hysterical simply require the down-running current, and that very light, and a short seance; while the lean, or the hardy, the cold in temperature, and the melancholic in temperament, seem to require the spring of the reflex action from an up-running current, whatever the battery or apparatus employed to give it. Where we are thwarted in the desired results, the electrodes may be positioned so as to run the current from the nape of the neck to the pit of the stomach, or *umbilicus;* or from the nape of the neck to the dorsal spine, or even as low down as to the sacrum, and thus maintain the current, *down-running*, i. e., direct, by part-minute stages, but always in one direction, whatever that is, when once chosen and we obtain good results. Indeed such a procedure cannot be systematically adopted with-

out some positively sensible results; and even if the headache seems to be awakened to more severity by a given current direction, the work is then half done, for you have obtained a diagnostic test that now guides you in the future, and you will be — you must be — successful in breaking up all merely functional, habitual, or periodical headaches, where there is no organic disease, nor any habit persisted in that as constantly perpetuates the malady.

*Treatment of Neuralgia.* — Most forms of neuralgia are obstinate of cure, or, more properly speaking, are *relapsing;* the many cases of which, taken in a strict sense, are not diseases in themselves, but appear either as the *herald* or *sequel* of some other disease or derangement, and often of a very slight derangement. But sometimes, even after the cause is removed, still the neuralgic pains recur, apparently from some abiding changed condition of the nerve, induced at first, as we have said, by some other disease or derangement of functions. But if the neuralgia is caused by wounds of the nerves, by inflammation, by hypertrophy, or by scirrhus of the neurilemma, or from disease of the great nerve centres, or from caries or exostosis of the bony passage through which the nerve passes, then it cannot be expected of any local electric treatments to cure the affection; nor indeed if it arises from any organic disease or *existing morbid states* of the liver, stomach, kidneys, uterus, or ovaries, &c.; nor yet if the affection is continued from repeated exposure to damp or cold, or from exhausting and irregular indulgences, or from over-working habits. But if the neuralgia arose even from some such cause, *which is now removed*, and the affection is merely *a morbid exaltation of sensibility*, without structural change or faulty function acting as an exciting cause, or if it is of a rheumatic origin, or of no assignable foreign or vicarious origin whatever, then can Faradaic or Galvanic electricity have a truly curative effect, and that by changing and thus permanently restoring the nervo-electric polarity of the deranged nerves. (See pp. 404-409.)

The excruciating pains of neuralgia are easily distinguished from those of rheumatism, mainly by the former following the

course of the nerves, or from their being fixed at the point of exit of a large nerve trunk from the bones, as the facial, trifacial, and sciatic nerves are examples. Some neuralgias, we have said, are evidently complicated with rheumatism; and they must receive a modified treatment, according as either of these characteristics predominates. The most grave and indeed frequent form of this is the sciatic neuralgic rheumatism; and these attacks are often occasioned by inter-pelvic causes, as well as from exposure to cold or damp immediately *after fatigue*. With an eye, then, on the origin of the affection, shape the plan for eradicating it; if this is not possible, then aim for toning it down to some more bearable kind or degree.

### *Neuralgic Patients, for Systematic Treatment, should be arranged in Three Classes.*

It has often been reported, by various medical men, and is generally believed, that if an *intense* current of electricity — Remak says *primary*, Duchenne says *secondary* — be so applied as to course steadily *down* a nerve for several minutes together, the sensory power in that nerve and its branches is benumbed; and that, therefore, the same result will follow the same proceeding if the nerve be the seat of neuralgic pain. After a time, the pain returns; but on repeating this action of the electric current each time as soon as the pain recurs, which is at longer intervals, a cure will finally be conquered.

M. Becquerel, of Paris, says he has so treated sciatica, lumbar, intercostal, crural, and trifacial neuralgias with complete success. Nineteen cases of sciatica, many of them old and obdurate, he cured by this method and process. But I have not been so uniformly successful by this method. True, it is a capital plan for a given class; but in only about one third of the cases, as a whole, did I succeed by this process; while in another quite as large a proportion of cases, success came only by smart faradization; others were relieved mainly by hypodermic injections; while others again proved to be incurable by any or all means, external and internal, brought to bear upon them.

The facts are the following, according to my own experience of many years: Where the electric current is so very strongly and continuously applied to a nerve *in a well, strong, and healthy person*, the immediate result, as above stated, is quite true. There is produced a temporary depression of nerve action; but the after reaction results in an ultimate *exaltation* of nerve action. So that after several such treatments, with a few hours between, the nerve arrives at a state the opposite of being benumbed: it, with its branches, is become actually hyperæsthetic. So, also, when electricity is applied to a nerve that is congested or inflamed, or is already deranged in its polarity, and is hyperæsthetic with *sthenia*, the result will be bad — that is, more pain, more nervousness, more hyperæsthesia. Whereas, if the same current, by the same method precisely, be applied to a neuralgic nerve in a state of *asthenia*, be it chilled, poisoned, or enfeebled by whatever means, if it is not inflamed, nor actually damaged at its root, the result will be happy; and by repetitions of this treatment it will become a success — a permanent cure.

So, then, in practice we discover a *law*, that there is *a class* of neuralgic cases, including very many of both acute and chronic, be they sciatic, lumbar, intercostal, or facial neuralgia, &c., where, besides this local neuralgia, *there is a general state of hyperæsthesia*, and perhaps *sthenic hyperæmia*, although the patient may seem weak and feeble. This state and characteristic in these cases may be ascertained by testing with the electrodes; for such a patient can never bear but the very smallest strength of electric current, and even that causes immediately, or speedily, an increase of pain or distress. For this reason such a patient needs to be prepared, before applying electricity, by very plain diet and active purgation; by an antiphlogistic plan, or small combined doses of antimony with belladonna or morphine, or by veratrum combined with tonics. If such a case is urgent, treat rather by the hypodermic injection of morphine or atropine — at least for temporary relief.

The *second class* of neuralgic cases we observe in practice is, the enfeebled, the anæmic, and even, sometimes, where there is

hyperæmia but with *asthenia*, or a passive form of weakness; where the electric current is exactly appropriate, and succeeds usually to a charm.

The third class is made up of mixed cases; the most prominent characteristic of which is, that *they can bear very strong galvanic or faradaic* currents with little effect, and with little or no suffering. For these cases we may boldly resort to faradaization, or at least to electrifying the nerves and muscles through large moist sponge electrodes with smart currents. They will also be benefited by bark, iron, and nux vomica. So that this class can be readily discerned and boldly treated. Thus we have three grand divisions of all neuralgic patients, with a great variety of complications too numerous here to mention.

If there is inflammation or spasm complicating the case, we must call in the aid of leeches, and salines or other purgations; or veratrum, tartar emetic, and opium. If there is anæmia, or much debility, we require rest, good food, and good air; iron and quinine, or strychnia and stimulants; if gouty or rheumatic, cachectic or syphilitic, the colchicum and iodide of potassium, or the bromide of potassium and biniodide hydr.; if still a very obstinate case, we may resort to hypodermic injections, to electro-cautery, or electro-puncture needles; faradaization with the wire brush, or the actual cautery and the moxa; or else to blisters and surgery.

The group of nervous maladies termed *neuralgiæ*, Dr. Harry Lobb, of London, says, according to his experience, generally yield more frequently to the continuous primary galvanic current. Of these he gives many examples. The following is a peculiarly instructive case, because we so frequently have similar ones to treat.

Case of Ann Wilson, aged fifty: "Has suffered with pains along the course of the sciatic nerve for the past year, sometimes so bad as to cause great difficulty in walking. The pain is chiefly in the hip and about the foot, and is sometimes very acute. She is never entirely free from it; otherwise she is quite well. I applied the *Pulvermacher* galvanic chain, (direct current;) also to have the skin over the painful parts occasionally stimulated

with the dry metallic electrode, (direct current.) This was persisted in for some weeks, but gave very slight and evanescent relief. I then thought of trying the *persistent inverse current*, seldom, though sometimes, most beneficial in certain neuralgia. The poles of the chain battery were changed; also the battery current. This gave immediate relief, and after five applications [but he does not say where the electrodes were applied, nor state how long each seance was] she was quite cured, and has had no return since, though now more than two months." I have noticed since that, in many cases of uterine affections complicated with neuralgia, when the uterus or any of its appendages is primarily affected, that the *inverse primary* current seemed to be required; and not the direct, which would in these cases almost always fail. I therefore conclude that this case of sciatica was the result of some uterine affection, as the untimely arrest of the menses, or from ovarian congestion.

From another stand-point all neuralgic affections may be arranged in three classes, thus: *a*, central; *b*, peripheral; *c*, reflected. The second of these classes Dr. Lobb "subdivides into idiopathic, traumatic, and neuromatus. The idiopathic *peripheral* neuralgia is known by the excessively excruciating, stabbing, darting pains in the course of the nerve affected, shooting along it like lightning, coming suddenly, lasting perhaps but a moment, and repeating at short intervals. The part affected with this form of neuralgia is usually colder, and the skin that is supplied by the neuralgic nerve very soon becomes more or less numb, not tender to the touch, the patient rather liking to have it rubbed, or have the part pressed. If this sort of neuralgia lasts very long, there comes on more or less paralysis in all the organs or muscles supplied by these branches of nerves. This neuralgia is not a hyperæsthesia of the healthy nerve function, for during health a nerve trunk or branch has no sensation *proper* in itself; if it be cut, struck, or torn, the sensation at that instant *is referred* to the parts where the terminal nervelets are distributed. By electricity it is speedily cured.

"A neuralgic nerve may be likened to an iron wire conductor of a large compound galvanic battery, which, if of ample size, conducts the given electricity along without being perceptibly

affected by its passage; but if a very small portion of the wire be any way disintegrated, or much finer than the rest, it becomes hot, red hot, because it is unable to readily transmit the whole of the current; therefore the remainder correlates into heat. So in a sick nerve, from mal-nutrition, or other cause, it is unable to transmit the normal sensations to the brain, and the nerve-current, by affecting the polarity of the nerve itself, gives thus the idea of pain in that portion of the nerve-trunk, and its peripheral terminals speedily become numbed; while the motor twigs from this stem become paralyzed."

The physiological doctrine that oleaginous materials abound in all nerve-cells, as an essential constituent, leads Dr. Radcliffe, of London, to recommend fat meats. That is, the diet best suited to *the neuralgic habit* of body, appears to be one which does not contain too much lean meat, nor too little fatty and oily matter. He also believes that a liberal use of sugar, and all sweets, as confectionery, &c., is very harmful to the neuralgic, by producing extra lactic acid in the blood. He also recommends for preventive and curative treatment of neuralgic pains the use of hot whiskey punch in the morning. He says, "I have repeatedly known a paroxysm of neuralgia prevented, and cut short, by a glass of hot grog." Doubtless this is a good prescription; we know it is for certain cases, but will fail in other certain cases; while it is a dangerous practice for most patients.

*For treating* hyperæsthetic sciatic neuralgia, choose the largest sized and softest sponge electrodes; place one — the positive pole, for example — over the exit of the sciatic nerve; i. e., just back of the most prominent bone on the outside of the hip and thigh, which is the *trochanter major*, in the hollow between it and the *ischium* bone, which spot is easily found from its being the seat of exquisite tenderness or pain; while the other sponge electrode is firmly applied on the terminal twigs, along down the foot, and there retained with a steady down-running (direct) current of electro-magnetism, or galvanism, *of bearable strength, for one minute;* then very carefully remove, or glide along the positive electrode some six inches down the limb for a half minute more, and then again, and again, in such short stages, until arriving at the ankle; in all some five or six min-

utes. The electrodes must be applied with the greatest possible gentleness, and removed equally so. Care must be taken not to touch the limb with any kind of shock, or reversed current, *not even for an instant.* The electrodes may be applied, skating along down the limb first one, every minute, and then the other, but always in the same order and at short moves. The lower — that is, the negative — electrode should never be placed above any painful neuralgic spot, but always aim to include between the two electrodes the painful nerve trunk, as well as the painful periphery. When the whole nervous system appears to be more or less implicated in the neuralgic or hyperæsthetic state, I then apply the positive electrode rather to the nape of the neck, at first, and then, by skating-like motions, from minute to minute, gently work it along down the back, not only over the spinous processes, but again on the muscles of the sides of the back, while the lower sponge is planted below all painful localities. I say, glide the positive sponge in stages gently along down the back, more slowly over the *cauda equina*, and so along over the hip or the crest of the ilium, and down the lower limb, tracing along the painful track. Let the seance last as long as the pain continues, i. e., never quit while pain or even soreness remains. If the pain returns within six hours, repeat the seance at once; but if merely some pain lingers here and there in after hours, then daily applications will suffice. If a moderate current is first used, and does not succeed, then bring a stronger one to bear upon the case. If this has been fairly tried, and, perhaps, faithfully repeated, and yet without success, then I change the mode of proceeding by applying the electrodes reversed, i. e., with an up-running current, *embracing only the nerve trunk* of the affected part. But these are rare cases. Where the neuralgic-like pain is seated, and proves obstinate, the *circle treatments*, daily repeated, will eradicate the last vestige.

We notice that M. Magendie was the first fairly to employ the primary, continuous galvanic current in the treatment of neuralgias. When the pain was in the face, for instance, he employed two *acu-puncture needles* to convey the current, the one from the positive pole inserted in the very spot where the painful nerve makes its exit from the bone, while the other needle was inserted

into the substance of the muscles that receive the twigs of that nerve. The negative needle was removed and then reinserted every few minutes wherever pain was felt, until all the pains were fairly chased away. But this was not always effected permanently until after several sittings. The needles were allowed to remain inserted for a little time, during which the patient was directed to make such motions as had usually before brought on the paroxysms of pain, and if any was still found to be produced, the current was repeated. This he termed "*electro-puncture*." But in other parts of the body he often used the sponge electrodes. By carrying out the rules and conditions already obtained by Nobili and Marianini, he restricted the use of the galvanic current to a *bearable strength*, and, in given cases, to *certain given current directions* as regards the affected nerves.

In all cases of pure neuralgia he always employed the positive pole of the battery towards or nearest to the nerve centre and over the nerve trunk, while the negative pole is placed over, or into, some portion of the ramifications of that nerve; so that the electric stream is *direct, when treating neuralgias*. But he held, also, that in case the current was employed in the opposite direction, and, if not too severely employed, the therapeutic effect would still more or less take place, it being in that case a *disturbing method*, which is, indeed, a very law in therapeutics; but then there would be a waste of remedial power, and a production of needless pain.

M. Becquerel advises to the employment of this powerful agent in the most gentle and agreeable manner possible, and for that reason he thinks it best to dispense with the needles, and employ moist sponges, using sometimes the secondary or Faradaic, and at others the primary or Galvanic currents.

Dr. James, a recent English author, gives it as his experience, that one, and the largest, class of neuralgic patients is best treated by the veritable, primary, and continuous galvanic current, of only moderate intensity; but he does not define the class, or say particularly how he directed the current.

It is my own experience that the neuralgias met with, in this country, are mostly of two quite distinct kinds, — or, at

least so they may be termed,—as relates to the successful adaptation of the different electric currents. If the operator cannot by tact or discrimination distinguish these at first, he will find that on applying the continuous galvanic current he will succeed admirably in some cases, but, perhaps, fail as signally in others; and not only so, but speedily aggravate the case. Now, if in this dilemma, he but just reverses the direction of the current and tries again, in a very few *seances* he will find his triumph, and that in the very same case where before he failed. And electro-magnetism may also be introduced in the place of galvanism with happy results, often, almost, if not quite, equal to the former, provided the same rules are observed as regards the direction of the current, and, at the same time, avoiding shocks and perturbations.

Whenever we find by proving, and have decided upon using a given direction of current in a case of neuralgia, this relative position of the two sponge electrodes, during all that *seance*, is to be strictly observed—i. e., for neuralgias; for one instant of a sudden and actually reversed current can get up an increased susceptibility that is rarely calmed again in that *seance*. My own practice is not to exceed ten minutes, in all, at any one sitting, and more frequently only five or six minutes, using a gentle current, and large, soft electrodes. The time of the whole sitting may be a half hour, or more if desirable; but the time I refer to particularly relates to the length of time the current traverses the nerves, or, rather, is applied to the skin. In case Faradaic currents are used, (i. e., electro-magnetism,) double the time may be profitably devoted to each sitting. Then, if the clearing out of the neuralgic pains is not effected by some half a dozen or dozen *seances*, it will be found that the pains are the result of inflammation, or but *symptomatic* of some existing morbid function that first needs to be set right, or of some more serious, and, perhaps, remote organic disease that is incurable.

I would only add here, as electro-magnetic machines are the more generally owned, and for other reasons, also, are more likely to be employed in these cases, that first class and fine coil instruments only should be relied upon. If the vibrations are coarse or irregular, and cannot be nicely graduated to a rapid,

even, and fine current, that nearly resembles the true primary galvanic current, then I should never touch a neuralgic patient with it. Success in these cases greatly depends on a smooth current with gentleness: the applying, the continuing, and removing the current without change of *density*, or change of *direction* of the current in the main, *is the rule here for treatment*. (See chapter on Rules, pp. 391, 459.)

In muscular and periphery neuralgia, as, indeed, in some other cases where the pains are more *diffused* and somewhat rheumatic, we can manage to observe this *law of application* for neuralgia, and yet, as it were, wash or bathe the part with the electric current. By beginning with a very gentle current of electro-magnetism, then after a few seconds or a minute, (and while the applied sponges are being very gently moved along over the skin,) let another person push the bundle of wires or iron rod a little further into the machine, to increase the current in the most cautious and imperceptible manner possible, and the patient will bear this *labile* movement of the electrode, and with it a larger current than could be borne if abruptly applied, or retained in one position when applied.

After no small experience in treating the various neuralgias by means of electricity, Dr. H. W. Lobb says he is now inclined to divide the whole family of neuralgias (as respects treatment by this means) into *two great divisions* or classes; the one requiring the "*direct*" current of Galvanism or Faradaism to effect a cure, while the other class is reached only by the "*inverse*" current. In this connection, he calls the direct current *stimulating*, and the inverse current *lowering*, *calming*, or depressing in its effects on such morbid nerve action. Therefore, he says, the sagacity of the physician must decide in a given case which current is best — is the right and only one to be used. He remarks further, that "during the month of June last, I had under my treatment, at the Western General Dispensatory, three cases of infra-mammary pain that was neuralgic. Dr. C. was present, and also desirous of making use of the so-called continuous (primary) current of galvanism, as a means of diagnosis and treatment, he having heard that I believed neuralgias to be, in this respect, of two distinct classes. There-

fore, the *direct current* was applied to two of these women, and that with very decided and immediate relief. To the third case, the *inverse current*, being indicated, was applied, which, in one minute, not only removed the pain, but consciousness also; in which state she remained for some ten or fifteen minutes. Upon restoration, she said that her side was quite numb. This was an instance not only of local but of general anæsthesia, produced, by the aid of the continuous current of electricity, in less than one minute."

It is to be regretted that, in so interesting a matter, the number and size of the elements, and kind of battery power employed, were not mentioned. But doubtless this was a very nervous or peculiarly impressible case, and gave not the ordinarily to be expected result of galvanic electricity, unless employed in just such cases, or else there is an outrageous battery strength brought to bear, that is entirely disproportionate to the nerve endurance of the patient, and hence dangerous. It is my own opinion, judging from the sketch of the case, that a too strong or too long-continued current was employed for the constitution or *condition* of that particular case; that is, the same current might have been borne for fifteen or twenty seconds, and even accomplished the purpose and no more, that so affected her in fifty; or half that current could have been borne the whole fifty seconds, with only good results.

But, again, as to the *two* classes of all kinds of the neuralgic for electric treatments. This interests me much, for it accords with my own experience. No doubt this affection may be set up in an organism under quite different circumstances, as in *astenia* as well as in *hyperamea*, and, indeed, in opposite conditions of the nerves, or body, in many other respects; therefore it is not strange that a different change of nerve polarity should be required for the restoration. The careful and correct application of the current itself in a given way, is the best diagnosis, for it will speedily restore or aggravate. In the latter case, change the *direction* of the current, and you triumph. Should you fail now again, you may judge that there is exposure, bad habit, functional derangement, inflammation, or organic disease.

*Superficial Nerves in the Facial Neuralgic Region.*

I wish now to pass in short review the exact anatomical relation of the nerves, and thus try quickly to refresh our memory by a bird's-eye view, as it were, *of the geography of the trunks and branches of the more superficial nerves.*

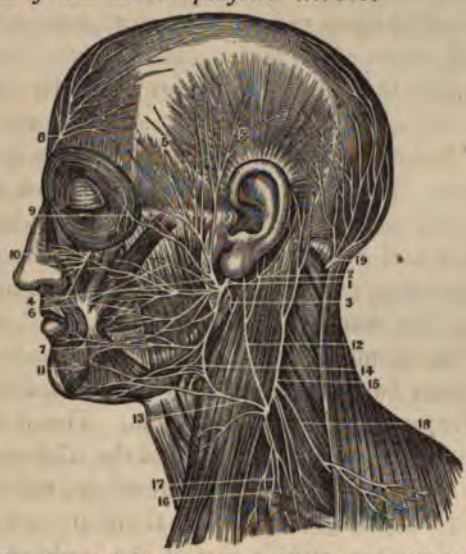



Fig. 113. A View of the Facial Nerve, together with the branches of the Cervical Plexus.

1. The Facial Nerve or Portia Dura, escaping from the Stylo-Mastoid Foramen. The Parotid Gland has been removed to show this.
2. The Posterior Auricular Branch of the Facial.
3. The Stylo-Hyoid Branch.
4. The Pes Anserinus.
5. Temporal Branches of the Facial Nerve.
6. Malar Branches.
7. Cervico-Facial Branches.
8. Supra-Orbital Nerve.
9. Sub-Cutaneous Malæ, a branch of the Superior Maxillary.
10. The Infra-Orbital Nerve, or second branch of the Fifth Pair.
11. Terminal Branches of the Inferior Dental Nerve, called Mental.
12. Nervus Auricularius of the Cervical Plexus.
13. The Superficialis Colli Nerve.
14. The Plexus formed by the last-named nerve and the branches of the Facial.
15. Occipitalis Minor Branch of the Cervical Plexus.
16. Descending Branches of the Cervical Plexus.
17. The *Phrenic Nerve.*
18. The Nervus Accessorius of the Eighth Pair.
19. The Great or Posterior Occipital Nerve.

We know that the tri-facial, or fifth pair, after leaving the skull, spreads out into the most complex distributions and anastomoses. There are *three* principal branches. The *ophthalmic* branch passes forward through the outer walls of the cavernous sinus, lying externally to the other nerves, penetrates the bony orbit by coming out at the *sphenoidal fissure*, and then divides into three branches; and it is exactly at, or from this point that *neuralgia* oftentimes radiates flashes of excruciating pains. The lachrymal nerve, which is the smallest of the three branches of the ophthalmic trunk, communicates with the fourth nerve, passes along the upper border of the external rectus muscle, traverses the lachrymal gland, and then divides into two cutaneous branches. The superior branch of it passes through the malar bone, and comes out again to be distributed upon the anterior temple and the cheek. The inferior branch of it supplies the conjunctiva, and terminates in the integuments of the upper eyelid, also communicating with the facial nerve. But it is the superior branch, just described as mounting up to the temple, and there being lost in the integuments, that is the seat of the most frequent attacks of neuralgia. The *frontal branch* is the smallest of the ophthalmic third of the tri-facial nerve, and gives off but one branch, the *supra-trochlear*, which passes inward and over the pulley of the internal oblique eye muscle, and ascends then along the middle line of the forehead, very superficially, giving filaments to the skin, to the inner angle of the eye, root of the nose, and also to the conjunctiva.

The *second* and larger branch of the tri-facial we know is called the *superior maxillary* nerve. It comes out forward, through the *foramen rotundum*, enters the canal in the floor of the orbit, and runs out at the infra-orbital foramen. Emerging then on the face, just beneath the *levator labii superioris* muscle, it here immediately divides into multitudinous branches, thus diffusing itself mostly at and about its issue, but sending some filaments to the lower eyelid, to the conjunctiva, to the muscles and integuments of the upper lip, nose, and cheek, and finally forming anastomosis with the *portio dura*. True, there

are groups of branches given off from the superior maxillary as it passed the *spheno-maxillary fossa*, which give the posterior dental, &c.; also during its passage through the *infra-orbital canal*, which latter gives the middle and anterior dental; but it is the group that radiates on the face, giving the cutaneous and superficial muscular filaments, that we most need to study here. We often find occasion to know that there are considerable filaments furnished by the orbital branch of the superior maxillary, that ascends along the outer wall of the orbit, receiving there a twig from the lachrymal, then plunging through a canal in the edge of the malar bone to enter the temporal fossa, supplying the temporal muscles and fascia, and is finally lost in the skin of the temple and side of the forehead, but communicating with the *portio dura*, the auricular, and the temporal nerves. A posterior branch supplies the back teeth, the alveoli, and their gums. The middle and anterior dental branches, before their distribution, form the superior maxillary plexus, and from this the filaments are given off that supply the pulps of the teeth, the gums, alveoli, and the mucous membrane of the *floor* of the nares and the palate. But the *cutaneous* and muscular filaments are the true terminations of this nerve, not only supplying the muscles, the skin, and the mucous membrane of the cheek, nose, and lips, but also form intricate plexus with the more superficial branches of the *portio dura*, and hence are often neuralgic.

The *Vidian* or *Pterygoid nerve* is one, that is here of the utmost importance for our study. This nerve arises from the sphenopalatine ganglion, traverses the vidian canal of the sphenoid, and then divides into two branches. But it is only the *external* branch that particularly interests us. This is called the *superior cranial* or *nervus superficialis petrosus*, which ascends *into* the cranium, and enters the hiatus, to unite with the facial nerve. And let us be reminded that it is very near the point where these two nerves anastomose that the *chorda tympani* branches off. This superficial cranial branch of the vidian, according to Arnold, presents all the characteristics of a cephalic nerve in its whiteness and toughness of structure. Thus we find, even

n the interior of the ear, a considerable branch of the tri-acial which is liable to become neuralgic.

Fig. 114. The Tri-Facial Nerve, or Fifth Pair; giving a view of the Distribution of its three grand Trunks.

The *inferior-maxillary* nerve is the *third* great division of the tri-facial. It first escapes through the *foramen ovale*, and immediately divides into two principal trunks, the *external* and the *internal*, which are separated by the external pterygoid muscle. I should have said that the inferior maxillary branch of the tri-facial is partly motor; and it is in the *external* branch of this, that we find nearly the whole of its motor roots. This *external* branch divides at once into four branches, which are distributed to the temporo-maxil[illegible].

1. Orbit.
2. Antrum Highmorianum.
3. Tongue.
4. Lower Jawbone.
5. Root of the Fifth Pair, forming the Ganglion of Gasser.
6. First Branch of the Fifth Pair, or Ophthalmic.
7. Second Branch of the Fifth Pair, or the Superior Maxillary.
8. Third Branch of the Fifth Pair, or Inferior Maxillary.
9. Frontal Branch, dividing into the External and Internal Frontal Nerves.
10. Lachrymal Branch of the Fifth Pair.
11. Nasal Branch. Just under the figure is the long Root of the Lenticular or Ciliary Ganglion, and a few of the Ciliary Nerves.
12. Internal Nasal Nerve, disappearing through the anterior ethmoid foramen.
13. External Nasal Nerve.
14. External and Internal Frontal Ner[illegible]s.
15. Infra-Orbital Nerve.
16. Posterior Dental Branches.
17. Middle Dental Branches.
18. Anterior Dental Branches.
19. Terminating Branches of the In[illegible]ra-Orbital Nerve, also called the [illegible]a-bial and Palpebral Nerves.
20. Sub-cutaneous Malæ, or Or[illegible]ital Branch.
21. Pterygoid, or recurrent Nerve [illegible]rom Meckel's Ganglion.
22. Five Anterior Branches of the T[illegible]hird Branch of the Fifth Pair.
23. Lingual Branch of the Fifth, j[illegible]ned by the Chorda Tympani.
24. Inferior Dental Nerve.
25. Its Mental Branches.
26. Superficial Temporal Nerve.
27. Auricular Branches.
28. Mylo-Hyoid Branch.

lary region. They are the *masseteric*, the *temporal*, the *buccal*, and the *internal pterygoid*. Then, again, the *internal branch* of the inferior maxillary divides into three branches, which are the *gustatory*, the *inferior dental*, and the *anterior auricular*. The gustatory supplies the side of the tongue, its papillæ, and the mucous membrane. The inferior dental passes on by the ramus of the lower jaw, enters the dental foramen, and runs along the bony canal in the jaw, giving off branches to the teeth and gums as it passes, and then terminates in two considerable twigs, the *incisive* and the *mental*. The former supplies the lower incisive teeth, while the mental branch escapes through the mental foramen, and there becomes superficial, to supply the muscles and skin of the chin, lower lip, and the mucous membrane of the lower lip; it also communicates with the *portio dura*.

Now, if we go back and trace the temporal, or the second of the four branches of the inferior maxillary, we find it at first turns around the posterior side of the neck of the lower jaw condyle, near the joint of the jaw, then goes up vertically between the articulation of the jaw and the anterior edge of the ear, where it becomes superficial, and then even sub-cutaneous, in the most superior portions of the temporal fossa. But at its root, and behind the condyle, it furnishes important anastomotic branches to the *portio dura;* thus uniting with the upper divisions of these motory nerves, to be together distributed and lost in the integuments of the temple, the surroundings of the eye, and in the upper lip. These deserve our particular attention, as likewise do the twigs of this nerve to the lobe of the ear, and those to the auditory cavity and pavilion, as also the communications with twigs from the cervical plexus, and from the lachrymal, sub-cutaneous malar, auricular, and facial nerves.

*Neuralgic Points.* — The, to us, *most important points* of the tri-facial nerve are, 1. The *point of exit* of the *lachrymal branch*, which is at the external part of the upper eyelid. This is what Dr. Valleix called the "palpebral painful point."

2. The *point of emergence* of the *frontal* nerve, or, rather, of its external branch, from the upper orbital foramen, called *the upper orbital point*.

3. The *point of emergence* of the *nasal* branch, which can be found at the upper part of the side of the nose, a little inside, and below the internal angle of the eye, and this is called the *nasal neuralgic point.*

4. The *malar* or inferior branch that *emerges* upon the cheek, through a groove in the malar bone, and passing through the fibres of the *orbicularis palpebrarum* muscle, is called the *malar neuralgic point.*

5. The *point of union*, in the interior of the ear, of a branch of the *superficial petrosal branch* of the *vidian* nerve, with a branch of the *portio dura* — a union which arises from the *chorda tympani*, and is designated as the *internal auricular neuralgic point.**

6. The point of emergence of the upper alveola and dental nerve, which may be called the *superior dental neuralgic point.*

7. The two very important points of emergence from bone are found first at the *infra-orbital foramen*, well known as the site of *tic douloureux*, and now called the *infra orbital neuralgic point;* the second is at the *mental foramen*, and called the *neuralgic point of the chin.*

8. The point in the *masseter* nerve branch, where it crosses

* I will remark here, — as we observe that this point is quite different from the superficial points, — that I think I find a *law*, that at the very point of bifurcation or *branching off* of nerves, as also at the point or larger spot of *anastomosing* and *interlacing*, that *there*, especially, (and next to the "points of emergence," and becoming superficial, as discovered by Valleix,) is the nerve more liable to become the seat of neuralgia, and that all the more according as these are more complicated at any given place. True, Dr. Valleix laid down *four different positions of a nerve* as most liable to become the seat of neuralgia; but I do not see what portion of any superficial nerve is left out, if we define, first, "the point of emergence," second, "the course of the nerve branches through the muscle fibres to become superficial," third, "the point where the nerve becomes superficial," fourth, "the point where the nerve has its ultimate superficial distributions." Besides, this is not sufficiently definite for a rule in practice.

I think I am justified, therefore, in mentioning *seven points* in the course of nerves that are peculiarly liable to be the seat of neuralgic pains: —

1. The point of *emergence* of the nerve trunk from bone or any deep seat.
2. The point of *branching off.*
3. The point of becoming *superficial*, or running very superficially.
4. The point of *interlacing*, as for plexus and ganglia.
5. The point of *anastomosing* with other nerve fibrils.
6. The spot of *ultimate ramification in the integuments.*
7. The spot of *ultimate ramification in the fascia and muscle fibres.*

the sigmoid notch, on its way to the masseter muscle, and this is called the *temporo-maxillary neuralgic point.*

9. The point of the *temporal* branch of the inferior maxillary nerve found between the articulation of the jaw and the anterior edge of the ear passage, which is called the *temporo-auricular neuralgic point.*

10. The point of the *lingual* nerve branch is found where it emerges between the sub-lingual gland and the tongue, and is called the *lingual neuralgic point.*

11 and 12. There is one more vastly important point which I must here speak of and designate as the *crown point of neuralgia;* but this does not strictly nor exclusively belong to the trifacial nerve. This point (or limited region) is found at the interlacing between the last twigs of the *frontal* and the *superficial temporal* branches on the one side, with those of the greater and lesser occipital nerves on the other. This *large spot* lies over the *sagittal suture*, and almost directly above the parietal protuberance; it was called by Dr. Valleix the "parietal painful point." Thus we have noted the marked neuralgic points of the greatest *sensitive* nerve, in the whole human body.

The great *facial*, or *portio dura*, is rather a motor nerve; but it makes such numerous interlacings with the facial and the cervical, that it at one time bore the nickname of "*nervus sympatheticus minor.*" Its trunk first emerges from the *stylo-mastoid foramen* and passes forward through the parotid gland, and at but a little under the ramus of the lower jaw it divides into two trunks, the *temporo-facial* and *cervico-facial.* These two trunks at once bifurcate into very numerous branches supplying the muscles of the face, forming loops mostly over the masseter muscle, and anastomosing with other nerves in its profuse ramifications over the peripheral regions of the face from the temple to the neck. It is at its first division into the two main branches, and just where it comes out of the parotid gland, which we find is close along under the angle of the lower jaw, that it may be designated as *the point most superficial* of the facial nerve. This is the most reachable point in cases of paralysis of this nerve.

*Superficial Nerves in the Occipito-Cervical Region.*

The first or highest four of the eight cervical nerves interest us here more particularly. It is the *anterior* branches of these upper four that, by loops of communication, go to form the great cervical plexus. This plexus we find to be situated upon the *levator anguli scapulæ* and *posterior scalenus* muscle, to be there partly covered by the posterior edge of the *sterno-mastoid*, but more completely by the *platysma*. The anterior branches of the *fifth*, *sixth*, *seventh*, and *eighth* cervical nerves will be examined with the *brachial plexus*, of which they form the greater part.

The *posterior* division of the first cervical nerve, also called the *sub-occipital* nerve, passes out of the spine between the occipital bone and the atlas, in the there triangular space, and at this spot forms a long ganglion *that connects with the second cervical*, and then divides into two branches, one of which soon becomes superficial, and again divides into a number of branches, which are all distributed to the integuments and muscles of the upper and back part of the neck; but the larger and longer branches mount upon the occiput and expand so as to cover the occipital region, and are traced even up to the parietal protuberance. The *anterior* branch of this first cervical nerve, and those of the three other upper cervical nerves, go, as we have said, to form the great anterior cervical plexus; but the *posterior* branches are those that just here most concern us. These not only form the smaller or *posterior* plexus, but seem to have an almost common destination; and that is, first, to supply the muscles of the back of the neck, to form numerous anastomoses, and then to become *cutaneous*. We find, by dissection, that the whole surface of the *nucha*, as high as the first four vertebræ, also as low down as to the seventh and eighth nerves, is occupied with a very remarkably profuse supply of these short posterior nerve fibres, that mostly terminate abruptly in the flesh, skin, and fascia along the spine, while their roots are thus embedded so near by in the spinal marrow.

The first *superficial nerve trunk* I will notice here, is the *supra-*

*ficialis colli*, which is formed of united branches from the second and third cervical nerves; it is found by the electrode as it crosses obliquely behind the external jugular vein at the anterior border of the *sterno-mastoid* where it divides into an ascending and a descending branch; the latter is lost in the skin and fascia of the side and front of the neck, even to as low down as the clavicle; while the ascending branch passes upwards to the sub-maxillary region, and by very numerous branches they supply the integuments as high up as the chin and the lower part of the face; it then anastomoses with the facial nerve.

The second of the larger *superficial nerve trunks* here, is the *auricularis magnus*, formed also of the second and third cervical nerves. This first curves around the posterior border of the sterno-cleido-mastoideus, and then ascends upon that muscle parallel with the external jugular as far as the parotid gland, where it divides into an anterior and a posterior. The former is distributed to the integuments over the region of the parotid gland, and to the gland itself, connecting with the facial nerve and with the external ear. The *posterior* branch pierces the parotid gland, crosses the mastoid process, and then divides into many branches which are spread out upon the posterior region of the *pinna*, and the integuments of the side of the head and upper neck.

But the most *superficial* nerve trunk of all, in this region, is the *occipitalis minor*, which arises from the second cervical nerve. It also curves around the posterior border of the *sterno-cleido-mastoideus*, but above the preceding nerve, and ascends also upon that muscle parallel with its posterior border, where it is easily affected by the electrode; and from here it divides and is distributed to the muscles and skin of the region, namely, to the *occipito-frontalis*, *attollens*, and *attrahens aurem*, &c.

The next most important and *superficial* nerve trunks are, the *acromialis* and the *clavicularis*. These are found as two, or sometimes three, large nerves, which, at first, proceed from the fourth cervical nerve; but leaving the ganglion, they immediately subdivide into numerous branches, all of which pass downwards *over* the clavicle, and are distributed to the integuments of the

*Superficial Nerves in the Occipito-Cervical Region.*

The first or highest four of the eight cervical nerves interest us here more particularly. It is the *anterior* branches of these upper four that, by loops of communication, go to form the great cervical plexus. This plexus we find to be situated upon the *levator anguli scapulæ* and *posterior scalenus* muscle, to be there partly covered by the posterior edge of the *sterno-mastoid*, but more completely by the *platysma*. The anterior branches of the *fifth*, *sixth*, *seventh*, and *eighth* cervical nerves will be examined with the *brachial plexus*, of which they form the greater part.

The *posterior* division of the first cervical nerve, also called the *sub-occipital* nerve, passes out of the spine between the occipital bone and the atlas, in the there triangular space, and at this spot forms a long ganglion *that connects with the second cervical*, and then divides into two branches, one of which soon becomes superficial, and again divides into a number of branches, which are all distributed to the integuments and muscles of the upper and back part of the neck; but the larger and longer branches mount upon the occiput and expand so as to cover the occipital region, and are traced even up to the parietal protuberance. The *anterior* branch of this first cervical nerve, and those of the three other upper cervical nerves, go, as we have said, to form the great anterior cervical plexus; but the *posterior* branches are those that just here most concern us. These not only form the smaller or *posterior* plexus, but seem to have an almost common destination; and that is, first, to supply the muscles of the back of the neck, to form numerous anastomoses, and then to become *cutaneous*. We find, by dissection, that the whole surface of the *nucha*, as high as the first four vertebræ, also as low down as to the seventh and eighth nerves, is occupied with a very remarkably profuse supply of these short posterior nerve fibres, that mostly terminate abruptly in the flesh, skin, and fascia along the spine, while their roots are thus embedded so near by in the spinal marrow.

The first *superficial nerve trunk* I will notice here, is the *super-*

to the *trunks* of nerves, or to those more circumscribed in destination.

Since the *Pneumogastric* nerve trunk is most superficial *here*, I will add that the *functions* of this important nerve are, according to M. Longet, as follows: —

1. From its origin *above*, as far as the superior jugular ganglion, the pneumogastric is *exclusively* a nerve of sensation.

2. The stimulation of its proper fibres, as by the electricity, at their extremities, has *especially* the effect of inducing the *reflex movements* of deglutition, chymification, circulation, and respiration. At the same time it would be a serious error to suppose that, if the excitor influence of these fibres were cut off, the reflex motor actions would necessarily be abolished.

3. *Below* the superior jugular ganglion the trunk of the pneumogastric represents a mixed nerve, exercising a motor influence, voluntary on some organs, involuntary on others. The voluntary power it owes to its *direct* motor fibres; the involuntary, to the *indirect* before enumerated.

4. The sources of innervation required, to maintain the function of an organ, are multiplied in proportion to its physiological importance. Thus the organic movements of the lungs, heart, and stomach are influenced by motor fibres coming from numerous points of the nervous system. It is the same with the movements of deglutition, and with the respiratory dilatation of the glottis and uterus.

5. The anastomotic branch of the spinal accessory, which, to the exclusion of every other nerve, presides over the vocal movements of the larynx, only represents a partial motor root of the pneumogastric.

6. It is neither correct nor rational to conclude that, because, in the absence of this anastomotic branch, the phenomena of respiration, circulation, and digestion continue in animals, the pneumogastric nerve must be mixed at its origin. The internal branch of the spinal accessory is only one of the sources through which the trunk of the pneumogastric receives motor filaments from the cerebro-spinal centre.

### *Superficial Nerves in the Cervico-Brachial Region.*

This neuralgic field embraces the whole *arm, hand, and shoulder*, up to the *occipito-cervical neuralgic region* on the one hand, as just described, and to the *dorsal neuralgic region* on the other. We said that the four *upper* cervical nerves were mostly involved in the last described region, and as such we have studied them; but we see here that the *lower four* of the eight cervical nerves, together with the first dorsal, go together to make up the starting point from the spine for the great *brachial plexus;* and

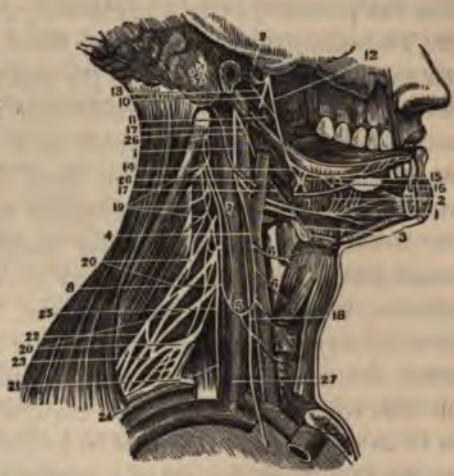


Fig. 115. A View of the Ninth Pair of Nerves, called the Hypo-Glossal; the deep-seated nerves of the neck are also seen.

1. The Hypo-Glossal Nerve.
2. Branches communicating with the Gustatory Nerve.
3. A Branch to the origin of the Hyoid Muscles.
4. The Descendens Noni Nerve.
5. The Loop formed with the branch from the Cervical Nerve.
6. Muscular Branches to the Depressor Muscles of the Larynx.
7. A Filament from the Second Cervical Nerve; and,
8. A Filament from the Third Cervical uniting to form the communicating branch with the Loop from the Descendens Noni.
9. The Auricular Nerve.
10. The Inferior Dental Nerve.
11. Its Mylo-Hyoidian Branch.
12. The Gustatory Nerve.
13. The Chorda Tympani passing to the Gustatory Nerve.
14. The Chorda Tympani leaving the Gustatory Nerve to join the Sub-Maxillary Ganglion.
15. The Sub-Maxillary Ganglion.
16. Filaments of communication with the Lingual Nerve.
17. The Glosso-Pharyngeal Nerve.
18. The Pneumogastric Nerve, or Par Vagum.
19. The Three Upper Cervical Nerves.
20. The Four Inferior Cervical Nerves.
21. The First Dorsal Nerve.
22, 23. The Brachial Plexus.
24, 25. The Phrenic Nerves.
26. The Carotid Artery.
27. Internal Jugular Vein.

hence are the *five spinal roots* of the nerves of the arm and hand.

We know, then, that the *brachial* or *axillary plexus* of nerves is formed by peculiar communications between the *anterior* branches of the four last cervical and first dorsal nerves; the fifth and sixth nerves unite to form a common trunk, which soon again divides into two branches; the last or eighth cervical and the first dorsal likewise unite, and soon again divide into two branches; the seventh cervical nerve passes outward between the two just described, and when opposite the clavicle it divides, and unites both with the one above and the one below, *and so unites the whole;* from which results the brachial plexus. This plexus is broad and deep-seated in the neck, but narrows and becomes superficial as it descends into the axilla, and then again enlarges some at its lower part, where it divides into its six terminal branches. It lies under the two *scaleni* muscles, between which its nerves issue, and lower down it is found placed between the clavicle and *sub-clavius* muscle above, and the first rib with the first serration of the *serratus magnus* muscle below. In the axilla this plexus is found situated by its outer border, resting against the tendon of the *sub-scapularis* muscle. At this point it completely surrounds the axillary artery by means of the two branches which are here sent off to form the nerve *medianus*.

Now, so very important is it for us to be familiar with the anatomical relations of the nerves of the upper extremities, that we must patiently review all the more important branches in the hand, arm, and shoulder. Commencing, then, at the roots of the arm nerves, we find there five pairs of spinal nerves, the fifth, sixth, seventh, and eighth cervical and first dorsal, whose *anterior* branches converge to form the great arm plexus. The *posterior* branches of the five pairs in question are far less in size and importance than the anterior; nevertheless, these small, short, and abrupt branches possess, here, no little interest for us. They at first set out merely vertically downwards, and then turn inwards between the muscles of the back, occupying the lower cervical and upper dorsal region, there throwing branches to the muscles as they pass, and then they

reach the surface *close along the spine*, and are reflected outward, to be distributed and lost in the integuments of the spinal region.

The larger *anterior* branches of these first five converge into the brachial plexus. From this plexus there go out together six terminal branches. These may be considered in two divisions; first, the humeral branches, or those that are found on the upper arm and shoulder; second, the descending branches, or those that supply the forearm and hand. Now, nearly all these nerves are in the first instance *motors*, i. e., first traversing and supplying the muscles; but they terminate by very many cutaneous branches of great importance. The first we notice are the *superior muscular nerves*, that go to the *sub-clavius*, the *rhomboid*, and the *levator anguli scapulæ* muscles. The next are the *short thoracic* nerves, (anterior,) which are two in number, and supply the *pectoralis major*, entering it, however, on its costal surface, and send twigs to the *deltoid*, as also to the deeper parts of the *pectoralis minor*. Next, we notice the *long thoracic* nerve, also called the *posterior thoracic*, or the *external respiratory* of Bell, passing down behind the plexus, but upon the broad *serratus magnus* muscle to its lowest serrations, where and in which it is lost, after supplying the whole muscle. Then we observe the *supra-scapular* nerve, descending from above the clavicle obliquely outward and downward to the *supra-scapular notch;* it then passes through the notch, crosses the *supra-spinous fossa*, beneath only the *supra-spinatus* muscle, (mark this!) and then passing in front of the concave margin of the spine of the *scapula*, it enters the *infra-spinous fossa*, and is distributed to the muscles *supra-spinatus* and *infra-spinatus*. Next are the *sub-scapular* nerves, two in number, distributed also to the muscle *sub-scapularis*. And, finally, still lower down on the shoulder, we find the "*inferior muscular nerves;*" they are only three branches, distributed to the *latissimus dorsi*, and the *teres major*. So much for the shoulder.

On the upper arm we notice the great "*external cutaneous*" nerve, which arises first in common with the *median nerve* from the cervical plexus, pierces the *coraco-brachialis* muscle, and

Fig. 116. A View of the Brachial Plexus of Nerves, showing its Branches to the Arm.

passes down between the *biceps* and *brachialis anticus* to the outside of the bend of the elbow; after supplying the integuments there, it perforates the fascia, and divides into two cutaneous branches. Thus the external cutaneous nerve first supplies the *coraco-brachialis*, the *biceps*, and *brachialis anticus* in the upper arm, and then the *integuments* of the outer or radial side (both the dorsal and palmar) of the forearm, from the elbow to the wrist, giving twigs also to the synovial membranes of the wrist joint.

The *internal cutaneous* nerve of the arm is smaller, and passes down the upper arm by the side of the basilic vein, giving off many cutaneous branches in its course. At about the middle of the upper arm it comes out of the deep fascia, and divides into several, all of which pass down the bend of the elbow, in front of or behind the *median basilic vein*, and descend in the course of the *palmaris longus* muscle, even to the front of the wrist, distributing branches to the integuments in their course, which is mainly on the palmar and outer margin of the forearm. The *lesser cutaneous nerve* arises from the great plexus, and is lost in the integuments back of the elbow, giving some twigs in its course to the middle posterior aspect of the

1, 1. The Scalenius Anticus Muscle.
2, 2. The Great Median Nerve.
3. The Ulnar Nerve.
4. The Branch from the Median to the Biceps Muscle.
5. The Thoracic Nerves; and just above is seen the Thoracic Loop, that supplies the Pectoralis Major and Minor Muscles.
6. The Phrenic Nerve, formed from the Third and Fourth Cervical.

upper arm, and connects with the first external *intercosto-humeral* nerve.

The *median* nerve arises also from the axillary or brachial plexus, and descends along the upper arm by the side of the brachial artery, to the inner bend of the elbow, where it passes between the two heads of the *pronator radii teres* and *flexor sublimis digitorum* muscles. It then runs down the very middle of the palmar face of the forearm, between the *flexor sublimis* and *profundus* muscles, and also beneath the annular ligament, then into the palm of the hand, *and so on to the palmar surface of the fingers.* Thus the terminal twigs of the *median* nerve supply the important "exquisite *sense of touch*" to the pulp of the hand and fingers. It also supplies the periosteum about the elbow joint, and at the wrist it throws a branch around on to the posterior aspect of the wrist, where it joins a ganglion of nerves that there give off numerous small branches for the supply of this joint. There is also a *superficial palmar branch* that arises from the *median* at about the lower fourth of the forearm, that crosses *over* the

Fig. 117. View of the Nerves, Arteries, and Veins at the bend of the Elbow, on the front of the Right Arm.

1. Lower Part of Cephalic Vein.
2. Upper Part of Cephalic Vein.
3. Anterior Basilic Vein.
4. Posterior Basilic Vein.
5. The Trunk formed by their union.
6. Basilic Vein piercing the deep Fascia at 7.
8. The Median Vein.
9. A communicating Branch between the deep Veins of the Forearm and the upper part of the Median Vein.
10. The Median Cephalic Vein.
11. The Median Basilic Vein. These regions can be seen.
12. Shows the *point* where the Three Branches of the Internal Cutaneous Nerve pass over or in front of the Median Basilic Vein.
13. Shows the divergence of these Three Branches, under which is the Tendon of the Biceps, and under that lies the Brachial Artery.
14. The External Cutaneous Nerve coming out of the deep Fascia.
15. The Internal Cutaneous Nerve.
16. The Musculo-Cutaneous Nerve.
17. The Spiral Cutaneous Nerve, a Branch of the Musculo-Spiral.

annular ligament, to be lost on the skin of the palm of the hand, and over the ball of the thumb. As the principal branch of the *median nerve* reaches the palm of the hand, I should have said, it spreads out flattened, and divides there into six branches — one muscular and five digital. The *muscular* branch goes to the ball of the thumb. The *digital* branches first send twigs to the *lumbricales* muscles, and then become thus distributed: two pass outward to supply the palmar sides or edges of the thumb; one goes to the radial side of the index or fore finger; one other divides into four, two of which go to supply the neighboring sides of the index and middle fingers; while the other two go to supply the neighboring sides of the middle and ring fingers; so that the outer side of the ring finger, together with the little finger, goes unsupplied from this source. As the digital nerves course along the inner lateral side or edge of the fingers, when opposite the base of the first phalanx each nerve gives off a *dorsal branch*, which runs along the border of the dorsum of the fingers. Then, very near the extremity of the finger, each digital nerve divides again into two, — a final *palmar* and a *dorsal* branch, — the former supplying the *sentient fibres* for the pulpy integuments of the balls and tips of the fingers, while the latter supplies the root of the nail, and the structures around and beneath it. *No*

Fig. 118. A View of the Nerves on the Front of the Forearm.

1. The Median Nerve.
2. Anterior Branch of the Musculo-Spiral, or Radial Nerve.
3. The Ulnar Nerve.
4. Division of the Median Nerve in the Palm to the Thumb, First, Second, and Radial Side of the Third Fingers.
5. Division of the Ulnar Nerve to the Ulnar Side of the Third, and to both sides of the Fourth Fingers.

*digital nerve ever holds any communication with its fellow on the opposite side of the finger;* hence each gives an independent impression; in effect, this arrangement is, as it were, "*a jury of ten,*" which certainly ought to give far more uniform and reliable judgment, than if every each were influenced by his fellow.

The *ulnar nerve* arises also from the brachial plexus, and passes along down the upper arm a very little back of the *median* nerve, but diverging from it more and more until it reaches the groove between the *internal condyle* and the *olecranon*, and crossing upon the internal head of the *triceps extensor*. Exactly at the under and back part of the elbow, this nerve is quite superficial, lying supported by the *inner condyle* of the elbow joint, against which it is easily compressed, as is often done by accident, giving rise to the thrilling sensation along the inner side of the forearm and little finger, usually ascribed to hitting the "funny bone." From this point the ulnar nerve passes between the two heads of the FLEXOR *carpi ulnaris*, and descends along the inner side of the forearm; crossing the annular ligament at the wrist, it divides into two branches — the superficial one going to the fingers by three terminal branches; the one of which is distributed to the ulnar side of the little finger; one goes to the neighboring borders of the little and ring fingers, and a filament to join the palmar median. The deep palmar branch passes between the *abductor* and *flexor minimi digiti*, to the deep palmar arch,

Fig. 119. A View of Nerves in the Back of the H arm, and Hand.

1, 1. The Ulnar Nerve.
2, 2. The Ramus Profundus Dorsalis Nerve.
3. Termination of the Nervus Cutaneus Humeri.
4. The Dorsalis Carpi — a Branch the Radial Nerve.
5, 5. Digital Nerves — a back view them.
6. Dorsal Branch of the Ulnar Ne

supplying the muscles of the little finger, and the *interossei*, and other deep structures in the ulnar side of the palm of the hand. There is also a *dorsal* branch of the ulnar nerve at the lower third of the forearm, that passes backward beneath the tendon of the *flexor carpi ulnaris*, and divides into two branches which supply the integument along that side of the forearm, besides two fingers and a half, on their posterior aspect. Another *anastomotic* branch of the ulnar nerve arises about midway down the forearm, and this divides into two; the one accompanies the ulnar artery, the other pierces the deep fascia outwards, and is distributed along the integument.

The *musculo-spiral* nerve is the largest branch of the brachial plexus. It passes downward in front of the tendons of the *latissimus dorsi* and *teres major* muscles, then winds around the humerus in the spiral groove to the space between the *brachialis anticus* and *supinator longus*, and thence downwards to the bend of the elbow, where it divides into two, the *posterior interosseous* and the *radial* nerve. The branches of the great *musculo-spiral* are, first, the *muscular*, which are distributed to the *triceps*, to the *supinator longus*, and to the *extensor carpi radialis longior*. The next is the *spiral cutaneous*, that becomes superficial just below the insertion of the *deltoid* muscle, and this passes down the outer side of the arm and forearm as far as the wrist, and is lost in the integument. The next branch forms the *radial* nerve, which runs along the radial side of the forearm to the beginning of the lower third of it; and here it passes beneath the tendon of the *supinator longus*, but at about two inches above the wrist joint it comes out again, piercing the deep fascia, and dividing into two branches. The external of these is distributed to the upper and outer or radial border of the hand and thumb. The internal branch crosses obliquely on the dorsum of the tensor tendons of the thumb, and divides into several filaments for the supply of the ulnar border of the thumb, the radial border of the index finger, and the neighboring borders of the index and middle fingers. The *posterior interosseous* branch separates from the *radial* at the bend of the elbow, as soon as

it leaves the parent trunk, pierces the *supinator brevis* muscle, and emerges from its lower border rather on the posterior of the forearm, where it divides into two branches, which supply the whole of the muscle on the posterior aspect of the forearm. The longest branch of this, called the *ramus profundus dorsalis* nerve, descends to a little below the posterior aspect of the wrist, where it forms a large gangliform swelling, (as often observed in nerves that supply joints,) and from which numerous branches are distributed to the wrist joint.

The *circumflex* or axillary nerve, arising from the brachial plexus, also passes downwards, but *over* the border of the *subscapularis* muscle, then winds around the neck of the humerus, and divides into numerous branches, which supply the muscle *deltoideus*. The branches of the circumflex nerve are both muscular and cutaneous. The muscular branches go to the *subscapularis*, *teres major*, *latissimus dorsi*, and the *deltoid* muscles. The *cutaneous* branches pierce the deltoid muscle after traversing its fleshy fibres, and are lost in the integument of the shoulder. One of these, which is the largest, (*cutaneus brachii superior*,) winds around the very posterior border of the *deltoid*, and divides into many filaments, which pass in a radiating direction across the back of the shoulder, and are lost in the skin of those parts, and particularly over the upper region of the deltoid.

The *neuralgic points* then, most to be noticed are, first, the terminal cutaneous nerve region of the posterior branches along the lower cervical and spine muscles. Second, a *neuralgic spot* over the spine of the shoulder blade, where the *supra-scapular nerve branch passes in front of the concave margin of the scapula*, to enter the *infra-spinous fossa*. Third, a *neuralgic spot* close under the outer end of the *clavicle*, where lies the lower end of the great *brachial plexus*. Another spot in the *upper anterior axilla*. Another on the *inner anterior neck of the humerus, where the several large nerve trunks for the arm first leave the great plexus, and here become superficial*, which makes them at once liable to neuralgia, but also accessible to the electrodes. Fourth, a *neuralgic spot* on the *pectoralis major* muscle, where the *loops* of the *anterior thoracic nerves* are lost in its

upper fibres. Fifth, a *neuralgic spot quite on the side of the chest*, and just by the anterior edge of the *serratus* muscle, where the long thoracic nerve trunk (external respiratory of Bell) is superficial on its way to the farthest serrations of this great respiratory muscle. Sixth, a *neuralgic spot immediately at or below the insertion of the deltoid muscle into the humerus, where the spiral cutaneous nerve emerges to become superficial.* Seventh, a *neuralgic spot over the border of the sub-scapularis muscle, extending to the posterior portion of the deltoid*, where the terminal branches of the axillary or circumflex nerve are lost in the integuments and superficial fleshy fibres of that region. Eighth, a *neuralgic spot on the middle of the posterior aspect of the upper arm*, where the lesser cutaneous nerve of Wrisberg emerges and becomes superficial. Ninth, a *neuralgic spot along the inner border of the whole upper arm, but more particularly at a point just above the bend of the elbow, and by the inner side of the tendon of the biceps muscle, where the great medianus nerve trunk becomes most superficial.* Tenth, a *neuralgic spot on the dorsal and radial aspect of the wrist and hand, where the dorsalis carpi*, which is also known as the *dorsal branch* of the radial nerve, mounts obliquely upon the extensor muscle of the thumb, and runs along superficially to the back of the thumb and fore finger. There is another liable to be a *painful spot* at the back of the wrist joint, over the nerve ganglia there; but this is not so frequently neuralgic, as rheumatic.

### *Superficial Nerves in the Dorso-Intercostal Region.*

There are *twelve* dorsal nerves on each side of the body: the first or upper one leaves the spine between the first and second dorsal vertebræ; the last or lowest one from between the *twelfth* dorsal and first lumbar vertebræ. These are distributed to the back, sides, and front portions of the body, both supplying the muscles and skin from the shoulder above, to the crest of the ilium below. This maps out the whole field of what is designated as *Dorso-intercostal Neuralgia.*

As each dorsal nerve root escapes from its inter-vertebral foramen in a downward and outward direction, the trunk immediately divides into two main branches, much as we have seen in the eight above; the one is called the *dorsal* or back branch, while the other constitutes the true *intercostal nerve*. The short posterior *dorsal branches* pass directly out backward, first distributing to the back muscles, and even to the deep *erector spinæ;* they then terminate profusely in the integument of this middle portion of the back, and even in the integument of the lumbar region in and near the middle line; so also some *external branches* are distributed to the skin and fascia upon the sides of the lumbar and gluteal region.

The *twelve intercostal nerves*, after receiving a filament each from the adjoining ganglia of the sympathetic, pass separately forward, running along in the intercostal spaces between the ribs, supplying the muscles as they pass, some terminating at the anterior termination of the intercostal space near the sternum; at this point the longer branches pierce the intercostal and pectoral muscles, then turning more downward and outward, are distributed to the integument of the mamma, and over the front of the chest. Those lower down, which are situated between the false ribs, pass behind the costal cartilages, and then outward between the muscles *transversalis* and the *obliquus internus*, then supplying the *rectus abdominis* muscle, and the integuments over the front of the abdomen. The first and last dorsal nerves come short of all this distribution. The branches of each intercostal nerve are, first, a *muscular branch*, (which has no cutaneous twigs;) and, second, a *cutaneous branch*, which is given off to become superficial *at about the middle of the arch of each of the ribs.* The cutaneous branches of the upper *three* intercostal nerves are not distributed on the body, but rise to radiate on the back of the upper arm, and hence are called the *intercosto-humeral* nerves. One of these is of a large size, and is widely distributed over the integuments of the back and inner aspect of the upper arm, as far down as the elbow. Another smaller branch is distributed to the integument of the extreme tip of the shoulder. One

other filament can be traced to the skin and fascia of the mamma. The *cutaneous* branches of the *fourth* and *fifth* intercostal nerves send anterior twigs to the integument of the mammary gland, and posterior twigs to the scapular region of the back. Then the cutaneous branches of the remaining, or lower *seven* intercostal nerves, arrive at the surface from between the serrations of the *serratus magnus* muscle above and the *external oblique* below, and these spread both backward and forward to all the surface of this anterior and lateral portion of the body. But the *cutaneous branch of the last dorsal nerve is remarkable for its size, and its ready response to the electrode.* It pierces the *internal* and *external oblique* muscles, and at once becomes superficial; then crossing the superior crest of the ilium, it is thrown into the integument over the dorsum of the ilium and of the gluteal region even as low down as the *trochanter major.*

To sum up, then, we find the *rule*, as first laid down by Dr. Valleix, that there are in each dorsal nerve three principal points, — i. e., that one is a point of "emergence," one of "superficial," and one of "distribution." The first is along the side of the spine over the intervertebral foramen, the second on the middle arch of the ribs, and the third along the side of the *sternum* and *linea alba.*

The first *series of neuralgic points* in the dorsal region, are found along the side of the spine, over the spot where these nerves emerge, which is about one inch from the side of the spinous process. The second *neuralgic spot*, here, is found along the back muscles, where are distributed to the skin all those short terminal twigs of the posterior branches of the dorsal nerves. The third great *neuralgic spot*, or *spots*, are found over the middle of each intercostal space; that is, at about the most prominent bend of the ribs, where the *cutaneous branch* bifurcates to become superficial. The fourth *neuralgic spot* is found but a little to either side of the sternum, or *linea alba*, where the terminal twigs of all the intercostal nerves become sub-cutaneous, and are reflected backward and forward over the integument, through all that region: particularly is this so just under or below the mamma; and that *is far more frequently*

*observed on the left* than on the right side. Another particular spot so abundantly supplied with surface filaments is *over the region* of the stomach, the pain there being more frequently ascribed to that viscus; another is near the umbilicus, and the pain there is often ascribed to the underlying bowels. The fifth *neuralgic spot*, in this field, is that just over the upper and anterior part of the crest of the ilium, where the last great *cutaneous branch* of a dorsal nerve *emerges*, so that its trunk is there superficial, lying on the external oblique muscle, to cross over to the dorsum of the ilium, and be broadly radiated in the *integument* over the great *glutei* muscles.

### *Nerves of the Lumbo-Sacral and Abdominal Region.*

In this *neuralgic field* we have to look at the remaining lower *eleven* pairs of spinal nerves. *Five* of these are *lumbar*, while *six* pairs are *sacral*. From the lumbar nerves results the great *lumbar plexus;* from the latter, the *sacral plexus;* then from these result the great nerve trunks of the lower limbs. But here we will confine our anatomical review to the "pelvic region," including the five lumbar vertebræ, the sacrum, and the sides of the pelvis, the lower part of the abdomen, and the genital organs.

Each of the *five lumbar nerves*, as they leave the intervertebral foramen, communicates first with the lumbar ganglia of the sympathetic, and then the *anterior* branch of each of them passes obliquely outward and downward back of the *psoas magnus* muscle, but underneath or in front of the *quadratus lumborum*, to both of which it sends a nervous supply. The first *posterior* lumbar branches pass directly backward from between the transverse processes of the vertebræ, and here each divides into two. The internal of these first supplies the *multifidus spinæ*, and the *interspinales*, then becomes cutaneous, and supplies the integument of the "hollow of the back," or lumbar region, on or near to the middle line. The external twigs of these *posterior* branches anastomose frequently, and so form loops, and after supplying

the muscles, they pierce the *sacro-lumbalis* outward, to reach the *integument* of the lumbar and upper sacral region, to which these also are finally distributed. The longer *branches* of the primitive five *anterior* nerve trunks that branch off while between the flat surfaces of the *psoas magnus* muscle, which lies beneath or beyond them, on the one hand, and the *quadratus lumborum*, that is over them, on the other, also form numerous anastomoses and loops, which, together with the last dorsal, constitute there the lumbar plexus. From this plexus there go out several branches that very particularly interest us here.

Fig. 120. A View of the Lumbar and Ischiatic Plexuses, showing the Branches of the former.

1. The Lumbar Plexus.
2. The Ischiatic Plexus.
3, 3. Abdomino-Crural Nerve.
4. The External Cutaneous Nerve, (Inguino-Cutaneous.)
5, 6, 7. Cutaneous Branches from
8. The Anterior Crural Nerve.
9. The Genito-Crural Nerve, or Spermaticus Externus.
10, 10. The Lower Termination of the Great Sympathetic.
11. The Iliacus Internus Muscle.
12. The Three Broad Muscles of the Abdomen.
13. The Psoas Magnus Muscle.
14. Bodies of the Lumbar Vertebræ.
15. The Quadratus Lumborum Muscle.
16. The Diaphragm.
17. The Sartorius, crossed by Branches of Nerves from the Crural, also from the Spermaticus.

The first are the *musculo-cutaneous nerves*, which are two in number, and known as the *ilio-scrotal*, and the *ilio-inguinal*. These pass together, and mostly from the upper lumbar nerves to the middle of the crest of the *ilium*, and there piercing the *transversalis* muscle, they each give off a cutaneous branch that passes over and out, to be lost in the integuments of the

upper and back portions of the hip. The main trunk of the musculo-cutaneous then winds along the crest of the ilium between the *transversalis* and the *internal oblique*, and at this point it divides into two branches — the *abdominal* and the *scrotal*. The abdominal branch runs forward parallel with the last dorsal or intercostal nerve, to near the rectus muscle, and supplying the muscles in its course, it then is distributed finally in the integument of the *mons pubis* and the folds of the *groin*. The *scrotal branch*, after communicating with the *inferior musculo-cutaneous* nerve, passes forward to the abdominal ring. It then pierces the *cremaster* muscle, and accompanies the spermatic cord in the male, and the round ligament in the female, to be distributed to the integument of the *scrotum* or the *external labium*. Such is the distribution of the *ilio-scrotal* nerve. The other musculo-cutaneous nerve, viz., the *ilio-inguinal*, passes at first obliquely across the *quadratus lumborum*, below the former nerve, to the anterior superior spinous process of the ilium, resting in its course upon the iliac fascia; but here it pierces the fascia and muscle of the transversalis outwards, and connecting with the scrotal branch of the *ilio-scrotal* nerve, it passes along the spermatic canal with the spermatic cord, to be distributed with it.

The *genito-crural nerve* proceeds mostly from the second lumbar, and passes downward and forward on the psoas muscle to Poupart's ligament, and divides there into two main branches — the *genital* and the *crural*. The *genital branch* (*spermaticus seu pudendus externus*) arrives at the internal abdominal ring, and descends along the spermatic canal, lying behind the cord to the scrotum, where it branches off to supply the spermatic cord and cremaster muscle in the male, and the round ligament and external labium in the female. Thus the scrotal branch of the musculo-cutaneous nerve and the genital branch of the genito-crural nerve together supply those important parts. At the abdominal ring, the genital branch sends off a large twig to the integument of the groin. The crural branch of the genito-crural goes to the thigh, and will there be considered.

We now come to the last six of the thirty-one pairs of spinal

nerves. These six pairs are known as the *sacral nerves*. The upper one, called the first, escapes from the vertebral canal through the first *foramen* in the sacral bone; the second, third, and fourth through their foramina; the two last from between the sacrum and the coccyx. These *anterior* branches interlace among themselves, and, with the lumbo-sacral, go to form the sacral plexus. Then from *it* are sent off to this neuralgic region the *visceral nerves*, which are in some three or four large branches, and arise mostly from the fourth and fifth sacral foramina; these ascend upon the *side* of the rectum and the urinary bladder; in the female upon the side of the rectum, the vagina, and the bladder. The *muscular nerve* branches go to the *levator ani* muscle; the *hemorrhoidal* nerve passes through the two ischiatic openings, and goes to the terminal portion of the rectum; also supplying the *sphincter ani muscle*, and the integument just about the anus.

The *internal pudic nerve* arises from the lower part of the sacral plexus, passes out of the pelvis through the great sacro-ischiatic foramen, below the pyramidalis muscles, and divides into two branches. The upper one (*dorsalis penis*) turns under and upwards to ascend along the posterior surface of the ramus of the ischium, and with the *arteria dorsalis penis* goes to the glands, in which it is distributed. At the very root of the organ this nerve gives off a cutaneous branch, which runs along its side, giving branches to the *corpus cavernosum*, and then, with its fellow of the opposite side, supplies the integument of the upper two thirds of the penis and prepuce. The interior branch of the pudic nerve divides, while in the perineum, into three principal twigs. The one ascends upon the outer side of the *crus penis*, and is lost in the scrotum. A second, called the *superficial perineal* branch, gives twigs to the scrotum, to the integument of the under part of the penis, and to the prepuce. The third branch, called the *bulbo-urethral nerve*, sends twigs to the *sphincter ani*, *transversus perinei*, and to the *accelerator urinæ*, and then terminates by profusely ramifying the *corpus spongiosum*. In the female, these branches of the internal pudic nerve are distributed to the parts analogous

to those of the male. There, the superior branch supplies the clitoris, while the inferior goes to the vulva and parts in the perineum.

The *lesser ischiatic nerve* passes out of the pelvis with the internal pudic. One of its cutaneous branches curves around the tuberosity of the ischium, ascends to the scrotum, and there divides. One branch is distributed to the inner surface of the scrotum, and to the testis. The external branch goes to its outer side, and both terminate in the integument of the under border of the penis, or, in the female, to the vulva.

To sum up, then, we find that the lumbar nerves give some large *posterior branches*, which are distributed to the loins, the sacrum, and nates; also, that the *three musculo-cutaneous branches* give off those that go to the muscles of the lower abdomen, to the folds of the groin, and to the scrotum or pudendum; another branch to the integument of the lower abdomen, and another to the skin of the upper and inner thigh. A genito-crural nerve-branch also goes to the integument of the scrotum, the groin, and the thigh. Then the sacral nerves give branches to parts in the vicinity of the coccyx; also posterior branches to ramify the muscles and integuments of the nates. Of these are the *hemorrhoidal nerves* to the rectum, the *vesical* to the bladder, the *uterine* and *vaginal nerve* branches to the vagina and uterus. A branch of the inferior gluteal goes to the *perineum*, and the integuments of the posterior parts of the thigh. Then there is the *pudic nerve* to the perineum, and to the penis, or vulva.

The most important *neuralgic spots* in this region are, first, *a series of points along the side of the spinous processes*, and but a little removed from the median line where the posterior branches of the lumbar and sacral nerves *emerge* from their bony passage — the former pierce the *lumbo-sacralis*, to become distributed to the integument over them; and again, *a neuralgic extent* along and near to the median line over their ultimate cutaneous distributions; and again, *a neuralgic spot* at the posterior part of the crest of the ilium, where some of the lumbar branches pass over its edge very superficially, and

almost vertically, to be distributed to the skin and superficial fascia of the gluteal region. Next, we find *a neuralgic spot* at the highest and middle point on the crest of the ilium, where the great *musculo-cutaneous nerve* gives off a large superficial branch.

Next, there is *a neuralgic point* at the anterior superior spinous process of the ilium, above the groin, where the *musculo-cutaneous nerve* gives off its abdominal branch, which is distributed to the *mons pubis*, the folds of the groin; and near here, too, the scrotal branch anastomoses, which is very liable to be a neuralgic spot. Another very liable *point is at the external abdominal ring*, (which may extend along the course of the spermatic cord,) where the scrotal nerve branch emerges from under the cremaster muscle to accompany the spermatic cord in the male, and the round ligament in the female, then to be finally distributed in the integument of the *scrotum* of the former, or in the *external labium* in the latter. The *ilio-scrotal nerve* also is often neuralgic, and excessively painful along the course of it *from the abdominal ring to the groin.* But perhaps the most frequently *neuralgic spot* we find in this region is *that over the internal abdominal ring, where the genito-crura nerve comes out a very little below Poupart's ligament;* from there this nerve descends to be ultimately distributed to the skin and fascia on the top and front aspect of the thigh as far as half way down to the knee.

*Rule.*—In treating these painful points and regions, *begin* the *seance* with the positive electrode placed *at* or *above* the highest painful point, while the negative is *below* or beyond the lowest site of pain; then move the positive, from minute to minute, towards the negative, until it is *below* the lowest site of pain.

### *Nerves of the Sciatico-Femoral Neuralgic Region.*

This simply embraces the lower limb. We have here then but two great nerve trunks to consider, viz., the *femoral nerve*, (crural,) on the inner and anterior aspect of the limb, and the great *ischiatic* (sciatic) *nerve*, on the posterior and outer aspect of the limb. The roots of these two great nerves are inter-pelvic, arising from the lumbar and sacral plexuses; and as the

*anterior* or *femoral nerve* springs mostly from the lumbar plexus, we will review this first. This nerve is the largest branch from the lumbar plexus; it *emerges* beneath Poupart's ligament into the thigh, just above the groin, where it is flattened, but immediately subdivides into a great number of branches, almost all of which are superficial. Of its first branches are *the cutaneous nerves*, two in number, which, after perforating the *sartorius* muscle, and there giving filaments, pierce the *fascia lata*, and are then distributed to the integuments of the anterior inner aspect of the thigh, over its middle and lower part, even down to the inner side of the knee. The most superficial branch is the *perforans*, that comes out of the upper part of the sartorius, and there communicates with the *genito-crural* nerve, then divides into many branches, which supply the surface of the anterior and outer aspect of the limb as far as the *patella*. Another branch comes out of the fascia lata at the lower third of the thigh, and descends over the inner condyle of the knee joint, and curves forward around to the front of the knee, terminating just below the patella. Besides these, there is an important surface branch, derived from the muscular branch that supplies the *vastus externus* muscle, which is found radiated to the integuments over the outer side of the lower third of the thigh. The *muscular* branches

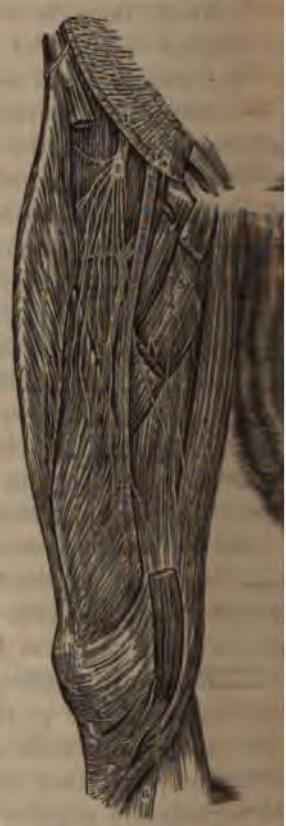


Fig. 121. A View of [illegible] Femoro-Crural Nerve, [illegible] ing also its Branches.

1. Point where this Nerve comes out under Poupart's Ligament.
2. Division of the Nerve into its numerous Branches.
3. The Femoral Artery.
4. The Femoral Vein.
5. The Branches of the Obturator N[illegible]
6. The Nervus Saphenus.

go to the muscles on the anterior of the thigh, as to the *rectus femoris*, the *vastus externus* to the *cruræus*, and a long branch to the *vastus internus;* and from this nerve large filaments go to the *periosteum* about the knee, and to the knee joint. We see that the *sartorius* receives its supply from cutaneous twigs. The branch to the *femoral sheath* enters it at once near the groin, and there surrounds the femoral artery and vein, and the profounder vessels; some of these re-unite and escape from the saphenous opening to pass downwards with that vein; others are distributed to the adductor muscles, and connect with the long saphenous nerve. The *short saphenous nerve* descends on the inner border of the sartorius to the lower third of the thigh, and is lost about the knee joint; but one branch accompanies the femoral vessels to the point opposite the termination of the femoral artery, where it divides and anastomoses with other nerves, as the obturator, &c., so as to form there a plexus, and from this, branches ramify the integument upon the internal and posterior aspect of the lower thigh. The *long saphenous nerve*, (*cutaneus internus longus*,) after leaving the femoral nerve trunk, accompanies the femoral artery to the aponeurotic canal formed by the *adductor longus* and the *vastus internus* muscles. It here quits the artery, passes between the tendons of the *sartorius* and *gracilis* muscles, descends along the inner side of the leg down to the front of the inner ankle, and is distributed to the integument *over the inner side of the foot*, as far as the great toe. But there is first a *tibial cutaneous branch* from this, that branches off a little above the internal condyle at the knee, and passes down, giving a constant supply of surface twigs over the inner aspect of the leg, even to the ankle; also another short branch that supplies the synovial membrane of the knee joint; also another that supplies first the integument over and about the patella and around the knee; then the skin and fascia on the front and outer aspect of the leg as far down as the ankle; and lastly, some cutaneous branches that come off from the long saphenous a little below the knee to supply the integument on the inner side and front of the leg and foot, and to give *articular* branches to the ankle joint.

We must here notice again *the obturator nerve*, which arises from the lumbar plexus, and with the obturator artery escapes from the pelvis to supply first the *obturator externus*, then passing in front of the *adductor brevis* muscle, supplying the *adductor longus* and the *gracilis*, and a branch ramifies the *adductor magnus;* then, from this, *a long cutaneous branch* proceeds to the plexus of the short saphenous nerve, and gives nervelets to the integument all along the inner side of the calf of the leg; but, before this, it gives some branches to the synovial membrane on the posterior aspect of the knee joint.

The *great ischiatic nerve*, excepting the brain and spinal marrow, is the largest nervous cord in the human body. It has its roots in the sacral and lumbar plexuses, but more directly from the latter. It is, indeed, the great prolongation or extension of the lower spinal nerves, but its large size forms only at, and not before its exit from the great *sacro-ischiatic foramen*, where it measures three quarters of an inch in breadth. It descends from beneath the *pyriformis* muscle, through the middle of the space between the *trochanter major* and the *tuberosity* of the *ischium*, and so along down the posterior aspect of the thigh, to about its lower third, where we see it divides into two, the *popliteal* and the *peroneal* branches. This division sometimes occurs farther up, but its course is always the same. The nerve in this route down the thigh rests upon the *gemellus superior*, the tendon of the *obturator internus*, *gemellus*

Fig. 122. A View of the Great Sciatic Nerve, also showing other Branches of the Ischiatic Plexus to the Hip and Back of the Thigh.

1, 1. The Posterior Sacral Nerves.
2. Nervi Glutei.
3. The Internal Pubic Nerve.
4. The Lesser Ischiatic Nerve, giving off the Peroneal Cutaneus, and,
5. The Ramus Femoralis Cutaneus Posterior.
6. Great Ischiatic, more frequently called the *Sciatic Nerve.*

*inferior*, *quadratus femoris*, and the *adductor magnus* muscles; while it is covered in, first by the *gluteus maximus*, then for a space by the *biceps*, and all along by the *semi-tendinosus* and *semi-membranosus*. The first branches from it supply the external condyle of the femur, and after this they pass on down to be distributed to the fibrous capsule, and to the synovial membrane of the outer side of the knee-joint.

Fig. 123. A View of the Popliteal Nerve, showing also some of its Branches.

1. The Popliteal Nerve.
2, 3. The Terminations of the Ramus Femoris Cutaneus Posterior.
4, 5. The Internal Saphenous Nerve, a Branch of the Crural.
6, 6. The External Saphenous, or Communicans Tibiæ.

The *lesser ischiatic nerve* passes out of the pelvis through the great sacro-ischiatic foramen also, and near by the side of the *great sciatic* nerve. These more local and superficial nerves curve their branches both backward and forward, to be distributed in the neighborhood of the hip. It first supplies the *gluteus maximus* even to its upper border under the crest of the ilium, while other branches turn backwards about the coccyx, and others go still farther down on the back of the thigh and leg. The *middle posterior cutaneous nerve* is one branch of it, and curves around and over the tuberosity of the *ischium* in company with the *scrotal* branch, then passes downwards superficially along the middle posterior aspect of the thigh, to be distributed to the integument along in the popliteal region both to the sides and back of the bend of the knee, and down as far as the middle of the calf of the leg.

The *popliteal nerve* is the "continuation" of the great ischiatic, from that point where the ischiatic (sciatic) nerve divides, to the arch of the *soleus*, from whence, it is then called the *posterior tibial nerve*. The popliteal nerve trunk is very superficial in all its course, and

is found external to the vein and artery. The branches are for muscular, articular, and cutaneous ramifications. One branch supplies the interior of the knee joint. The *communicans* is a large branch of the popliteal, which interlaces with a large branch from the peroneal nerve, (which is from the femoral,) and these two together constitute the roots of the *external saphenous nerve*. Then this external saphenous becomes superficial on the upper middle of the posterior calf of the leg, rather inclining to the *outer* border of the *tendo Achillis;* it then winds around the outer *malleolus*, and is distributed superficially to the *outer* side of the foot as far as the little toe. The popliteal nerve also gives off the *posterior tibial nerve*, which runs deep-seated until it arrives at the ankle, after passing down the *inner* side of the *tendo Achillis;* and here some *cutaneous* branches pass down the inner side of the *os calcis*, to be lost in the integument of the heel. There are some branches of the posterior tibial nerve that entwine about the fibular artery, and supply the *flexor longus pollicis*, and then become superficial, to be distributed to the integument on the back of the leg and heel. The *internal plantar nerve* branch seeks the sole of the foot, and lies between the *abductor pollicis* and the *flexor brevis digitorum* muscles; but at the metatarsal bones it divides into three branches. *One* supplies the adjoining sides of the great and second toe; the *second* supplies the adjoining sides of the second and third toe; and the *third*, the corresponding sides of the third and fourth toes. This order is the same precisely as we observed in the hand by the digi-

Fig. 124. A View of the Posterior Tibial Nerve in the Back of the Leg.

1, 2. Indicates its course and its Branches, the upper part of the Peroneal Nerve being seen to the right.

tal branches of the median nerve. The plantar nerves supply the integument along the inner sole and side of the foot, also the articulations of the tarsal and metatarsal bones. The *external plantar* branch gives nervelets to the integument along the outer border and sole of the foot, and then sends forward two digital branches to supply the little toe and one side of the next toe.

The *peroneal nerve*, we know, is one of the principal terminal branches of the great ischiatic nerve, the *popliteal* and *posterior tibial* being the other forks. And this bifurcation, we know, takes place above the popliteal space. This nerve passes outward and downward by the side of the inner hamstring, or tendon of the biceps, crossing the inner head of the *gastrocnemius*, and the origin of the *soleus*, to the neck of the *fibula*, and there emerges from under the origin of the *peroneus longus* muscle, and then divides into the *anterior tibial* and the *musculo-cutaneous*. From the peroneal nerve there is first the *communicans peronei*, which crosses over the external head of the *gastrocnemius* to the middle of the leg. It then sends a large branch to unite with a large branch from the communicans *poplitei*, and so constitutes the *external saphenous* nerve ; it then descends to the external ankle, to which, and to the integument of the heel, it distributes nervelets.

Fig. 135. A View of the Termination of the Posterior Tibial Nerve in the Sole of the Foot.

The *cutaneous* branch of the peroneal

1. Inside of the Foot.
2. Outside of the Foot.
3. The Heel.
4. Internal Plantar Nerve.
5. External Plantar Nerve.
6. Branch to the Flexor Brevis Muscle.
7. Branch to the outside of the Little Toe.
8. Branch to the space between the Fourth and Fifth Toes.
9, 9, 9. Digital Branches to the remaining spaces.
10. Branch to the internal side of the Great Toe.

nerve passes down the outer side of the leg, supplying the skin and fascia on its way to the dorsum of the foot, where it ramifies the integuments as its ultimate distribution. The *anterior tibial nerve* branch passes down beneath the *extensor communis digitorum*, passes under the annular ligament at the instep, supplies the adjoining sides of the great and second toes; it also gives twigs to the *interossei* muscles on the outer dorsum of the foot, and to the articulations of the *tarsus* and *metatarsus*. The *musculo-cutaneous* branch (mark !) passes down over the *fibula* in the substance of the *peroneus longus* muscle, but at the lower third of the leg it emerges, and branches superficially; one of these goes to the top of the foot, and then to the toes, passing in front of the outer ankle bone. In fact, this branch divides on the top of the foot; one branch then subdivides, to supply three and a half toes, and the other branch one and a half.

Fig. 126. A View of the Anterior Tibial Nerve.

1. The *Peroneal* Nerve, a Branch of the Ischiatic. 2, 3. The Anterior Tibial Nerve, accompanying the Anterior Tibial Artery down the Leg, and on the Foot.

Now, to sum up what we learn from clinical experience, as well as from anatomy, and by comparing, we find in this region the *neuralgic spots* to be, first, at the exit and ultimate ramification of the *nervi glutei* on the side of the hip, and where many lumbar branches also terminate, which pain is very often mistaken for rheumatism, or some affection seated in the great sciatic nerve trunk. Next, a *neuralgic spot* is found *about the tuberosity of the ischium*. Next, is the most remarkable *neuralgic spot* of all, which is *about half way between the ischium and the trochanter major; and this point*, we know, *is over the emerging spot of the great ischiatic nerve trunk, and is the more usual*

*seat of all sciatic tenderness and pains.* Next, we find a *neuralgic point* over the course of the *middle posterior cutaneous nerve trunk*, and also *in the popliteal space* where it is distributed; a *neuralgic spot* at the external condyle of the femur; a *neuralgic spot over the course of the popliteal nerve*, and another at its termination. Another *neuralgic spot* is found over the superficial trunk of the *external saphenous nerve*, on the middle calf of the leg, and along the outer border of the tendo-Achillis, and at the root of the little toe. Another *neuralgic* spot is some two inches below the knee joint, on the outer aspect of the leg, *where the peroneal nerve trunk emerges* to become superficial; and another spot at the outer ankle joint and heel, where it terminates. And finally, we find a *neuralgic* (and gouty?) *spot* at the terminal twigs of the great sciatic nerve, through the anterior tibial, which we know is mostly on the big toe.

Now, if we examine the *anterior* aspect of the lower limb, we find the first and most frequently *neuralgic spot immediately under Poupart's ligament, where the femoral nerve trunk emerges, and there becomes superficial.* So, indeed, is all the anterior and inner part of the thigh very prone to neuralgic pains, because the femoral or sacral nerve is superficial, and throws nearly all its ultimate ramification of nervelets into the integument over this space from the groin to below the knee, but particularly over the inner condyle of the knee, over the middle of the *sartorius* and *rectus femoris* muscles, also *just below the knee-pan.* Next, we often find a *neuralgic spot over the exit of the short saphenous nerve*, along the inner border of the sartorius muscle; then again *over the long saphenous nerve*, but more particularly at its termination *along the inner ankle, and about the inner side of the great joint of the big toe.* And finally, we find liable to neuralgia *the spot of emergence* of the *cutaneous branch of the internal saphenous nerve, which is about the middle of the thigh*, and where many other nerves also become superficial; and another *spot* might be mentioned, and that is, *the ankle joint.* This may be doubted by some, as pains here are usually referred to sprain or rheumatism;

but we must recollect that in and about this articulation are spent the ultimate ramifications of many nerve twigs, but especially those of the *internal saphenous nerve*.

I should advise you, medical students, to cultivate the habit of looking upon the nervous system *as a whole;* all the parts of which act and react upon each other. It *may* be true that every nerve in connection with the spinal cord consists of the five distinct nerves that some writers represent, viz., *volitional*, *sensual*, *incident excitor*, *reflex motor*, and the *sympathetic;* but it certainly is *not proved*. On the other hand, if you conceive *all the nerves to be subject to the same general laws, but having different functions*, in virtue of a difference in the apparatus on which they are distributed, and in the centres on or from which they act and react, you will, I think, arrive at results as comprehensive as the fivefold division affords, but much more comprehensible, and much more applicable to every-day practice. The physiology of the nervous system must be carefully studied if you would practise medicine and surgery successfully, and to this end electro-physiology is become indispensable.

## *Pain.*

*Pain*, sheer pain, — a simple functional derangement it may sometimes be, — can completely overwhelm the nervous system by its mere magnitude and *duration*. Suffering alone may kill; although it may be but a fragment of a malady, which malady of itself might, or might not, have been ultimately fatal, or curable. The same pain that would sooner or later kill if continued, when cut short, or mitigated, may bring the patient only to the verge of death, but still allow him to live. Now, pain is the adjunct of very many diseases, and so crying, so urgent, is it sometimes, that, practically, it becomes the representative of the whole malady — the main indication of treatment, superseding all other indications for the time. The whole business and skill of the physician, in this range of cases, are with the nervous system. All the power and all the expedients of his art are needed to lull it, and, if possible, to lay it to partial rest, or to

sleep from its agony; and at the same time to hold it up in its weakness, and prevent it from sinking into death.

An excellent article recently written by Dr. P. M. Latham, on this subject, quotes Dr. Barrett, where he relates the case of a person in apparent health who died from the sheer suffering of pain caused by gall-stone. The nervous system was simply overwhelmed, by the agony of impacted gall-stone in the cystic duct, unattended with inflammation. After continued suffering for sixty hours, the patient became cold, pulseless, and delirious, and so died. After death, nothing at all was found to account for it but this gall-stone. Dr. Gooch, also, gives the account of a lady in whom the most violent pain and expulsive efforts still continued after her child was born, until she became cold and delirious, and her pulse gradually went out, and she died. After death the excessive and continued pain was found to have been owing to a simple polypus situated just within the uterus. He remarks, "What a striking proof that pain, only, can actually destroy life!"

In sacred history there is recorded a preëminent instance of *death from pain*, or *pain unto death;* for, "*He gave up his life*" — no man took it. It was death of a perfect man in health, in the prime of life, and of the highest endowments, with pangs of mental agony and physical sufferings — tortures of the nervous system, which, by overwhelming exhaustion, terminated fatally the same day. I refer, of course, to the horrible death on the cross, by Christ, our blessed Lord and Savior. The bloody sweat was only secondary, being but the evidence of unspeakable distress; while the nails, the thorns, the toil and taunts, and scourge, and the soldier's spear, were only necessary agents for expediting the awful end.

The coarse iron spikes which were rudely hammered through those hands and feet must have lacerated nerve cords, muscle tendons, and bony ligaments; and as the continued hammering buried the points of the great nails deeply and firmly into the wood of the cross, the wedge-like shape of these irons must have torn and pried apart the metacarpals of the hands, and the metatarsals of the feet, thus producing the most insufferable phys-

ical agony. Then, again, when the cross was set upright, and fixed in the ground, with the whole weight of his body hanging upon the quivering nerves of the palmar arches, without one moment's release, and exposed as he was, naked to the sun and heat, who shall tell the sum of such sufferings?

"It was the *third* hour, and they crucified Him. And when the *sixth* hour was come, there was darkness over the whole land until the *ninth* hour. And at the *ninth* hour, Jesus cried with a loud voice, and gave up the ghost." (Mark xv. 25, 33, 34, 37.) Six long hours of conscious, and unmitigated, dying agony! The contemplation is very awful; and yet, there must be added to all this an unfathomable anguish of spirit, that embraced a God-like comprehension of the magnitude of the sins of the whole world. How emphatically was this *a painful death!*

*Local Traumatic Pain arising from Injury of a Nerve.* — This may occur from one or more of three induced conditions: *first*, inflammation of the nerve; *second*, pressure on the nerve; *third*, altered nutriment at the periphery of the nerve twigs. We know that when a nerve is completely severed, there is palsy. But when the spine, plexus, or a nerve is *partially* severed, crushed, or otherwise injured, there may result one or more of the three conditions just named; the sequel to which will be a chronic pain, in character either neuralgic, aching, or burning; or these may be mingled or alternated. The scar or site of the original wound, as also the track of the injured nerve, should be carefully examined by pressure, by faradaic electricity, or by hot and cold applications. If a lingering tenderness, not simply hyperæsthetic, but which *increases* with the increased pressure, thus showing inflammation, there should be a free use of leeches, applied over the region of injury and tenderness, which is of first importance. Next, keep the part elevated. Give opiates, tonics, and alteratives; if urgent, employ the hypodermic injections of morphine, or a pill of opium may be passed every evening into the rectum.

If there is evident pressure on the nerve from a healing contraction or ligamentous deposit in the cicatrix, as may be ascertained by certain positions, such as would produce its tension, then there should be made moderate, but gradually increasing,

motions of the part, with gentle shampooing, and then deep-shampooing and mellowing the parts in the region about. Although somewhat increasing the pain, at first, by persevering in these means it will be completely overcome; and then natural movements will confirm the cure. But if neglected long, or the patient refuses, this injury can become irreparable.

If the pain or distress arises rather from altered nutriment in the region of the terminal nervelets in the skin, or in the muscles, or both, there apply extensive and quick-working blisters, as the *collodium cum cantharide*, or the firing-iron. If repeated, either of these will cure. For temporary relief apply moisture, such as a wet cloth.

Neuralgia *following* the healing of wounded nerves, and from wounds involving nerves in the cicatrix, is very embarrassing. Dr. J. Mason Warren, of Boston, has recently reported some very interesting results of his observations on this subject; several cases occurring in his practice in which the injury was evidently in the tissues, about the nerve-trunk, rather than in the nerve itself. He found by exploration that the nerve was firmly glued to the surrounding tissues. Their adhesion being separated by operation, perfect relief from pain followed; which, however, returned in a diminished degree after cicatrization. The pain was then controlled for six months by the daily use of hypodermic injections of morphine until cured. Other like cases, he says, illustrates the controlling and curative effects of these injections, which not only relieved the pain, but actually cured it.

The natural tendency of these cases is to recover, according to the above results, if we can keep the patient comfortable during the necessary time for recovery to take place; either aiding the process by dividing the conglomerated tissue, else the nerve, and by the general or local use of narcotics.

*Neuroma* is a morbid enlargement of a nerve, or a sub-cutaneous, circumscribed, and highly painful tumor involving the tissue of a nerve cord. There is also a painful tubercle, of the size of a pea, which is now and then met with in the course of nerves, which appears to be formed from the neurilemma. And

besides these there are spots of undefined and indefinite hardness that form in the tissues of the body and limbs, which occasionally embrace nerve-cords, and prove not only painful, but most provokingly intractable. I believe them to be rheumatic and simply an exudation of coagulable lymph — to be treated by electro-puncture, and are sometimes thus quite curable, and are also some of those more undeniable neuroma. But there should be an active alterative treatment combined with the electric in all these cases.

*Pains about the Loins.* — Dr. Oke says, most truly, that there is no symptom more commonly met with in the general practice of medicine than "pain in the loins." To arrive at its *true cause*, in any given case, we must try to ascertain what function is principally involved; we propose, —

1. If the pain be *rheumatic*, it (soreness) will be increased by pressure on the seat of pain; and still more, if it be neuralgic, if pressure be made over the origin of the nerves there distributed. If rheumatic, the pain will be increased by the slightest action of the affected muscles. There will also be rheumatism or neuralgia in other parts of the body or limbs; the system will not be much disordered; the urine will be high colored, and deposit the lithates. Thus we may know it is lumbago.

2. If from disease of the spinal column, the pain will be aggravated by percussion upon or along the sides of the spinous processes at this portion of the back, or by suddenly striking the toes against an uneven surface. There will be involuntary action of the muscles, especially of the flexors of the legs, diminished temperature, abnormal feelings, and more or less loss of power of the lower limbs. The spinous process of the affected vertebræ may possibly be projected, and this would confirm it.

3. If from a collection of matter in or about the psoas muscle, if *unconnected* with spinal disease, then the pain will be continuous, dull, and deep-seated; extending from the loins down the *psoas*, or in whatever direction the matter may have taken its course. The pain will be increased by flexion of the thigh, and there will be difficulty in walking; moreover, there

will be marks of a strumous habit, and more or less symptoms of hectic fever.

4. If the *loin pain* originates in irregular *hepatic* function, then the pain will shoot upwards along the splanchnic nerves to the scapulæ; the alvine evacuations will show deficiency, alteration or excess of bile; the urine will have a bilious tinge, there will be a congestion of the hemorrhoidal veins, and the spirits will be depressed.

5. If the *loin pain* arises from deranged *duodenal* function, then it will be noticed that about three or four hours after a meal, the pain will be aggravated, shooting through towards the right side of the abdomen, and continuing more or less until the food has passed from the duodenum into the jejunum. If this be the case, dyspeptic symptoms will prevail, and there will be likely to be painful pustules breaking out about the face. This last symptom, however, is not uniform, though frequent.

6. If the *loin pain* is from the *kidneys*, it will shoot down the course of the spermatic nerves, towards the round ligaments in the female, or towards the testis in the male, which will often be retracted by the action of the spermatic nerve upon the cremaster muscle; and there will be more or less irritation communicated to the mucous membrane of the bladder. Then the urine will deposit mucous, calculous matter, blood, pus, or albumen, or it may be otherwise morbid in its composition.

7. If the *loin pain* be from the *uterus*, then the pain will be greatly in the back, and arise either from *disordered function*, or from *disease* of the uterus. In the former case the pain will be more of a neuralgic character, and it will return in forcing paroxysms, extending all around the hips and hypogastric region; will often be attended with some hysteria, or with increased menstrual discharge. In the latter case, that is, if from organic disease, the pain will be *constant* and severe, extending along the anterior crural nerve half way down the thighs. There will probably be a thin, offensive discharge from the vagina. The countenance will be wan and sallow, exhibiting the wear and tear of organic lesion.

8. If the given *loin pain* proceeds from the *colon*, there

will be constipation, or *inflation* along the course of the bowel, or the fecal discharges will be of small and perhaps flattened diameter, or there will be marked soreness of the intestine under pressure; especially is this found along its ascending or descending portions, and is attended occasionally with passage of mucus or shreds of lymph, much in the form of a yellow soft jelly or phlegm, but more frequently as wet bits of drab-colored ribbons, stretching along on the outside of the hardened alvine excretions. (See pp. 466-7.)

The correct *diagnosis* of painful nervous affections of the hip is of the utmost importance, and yet is not always so easy. I will therefore sum up the different characteristics or peculiarities of six of the most distinct affections of the hip, that may here be confounded, or mistaken the one for the other, viz.: true *sciatica*, *neuralgia*, *coxalgia*, *rheumatica*, *disease of the spine*, and *disease of the pelvic bones*, among which we may reckon the *sacro-iliac disease*. According to Dr. Frank Hamilton, professor of surgery at the Buffalo Medical College, and Dr. John Erichsen, professor of surgery at University College, we may keep our eye on the following peculiarities: —

1. *Sciatica* occurs usually in persons of middle or *advanced* life; the seat of the pain being back and below the articulation, and extending down the back of the limb, and there being no elongation of the limb, will enable us to effect the diagnosis here.

2. *Neuralgia* occurs at all ages; but the peculiar neuralgic pain, following the course of the nerves, or manifested over the ramification of certain superficial nerve branches, or the widespread and superficial pain and soreness, or the coexistence of the "hysterical joint" and hysterical temperament, the sex of the patient, and the absence of all actual local disease, is sufficient to make the case clear; but in young females it may be most readily confounded with the ulcerative sacro-iliac disease. The obliquity of the pelvis which sometimes occurs in the simple neuralgia, and "hysteria of the hip," causing *apparent* elongation of the limb, is readily detected, and is diagnostic, for it is removed for the time while the patient lies upon her back.

3. *Coxalgia.* — Hip disease may occur at all times of life; but

we must look out for that variety of hip disease that commences in the *acetabulum*, and primarily involves the pelvic bones, and only secondarily implicates the great joint. In hip disease the patient suffers most if pressure is made deeply just back of and above the trochanter, in the hollow behind that osseous prominence, or where pressure is made against the anterior part of the hip joint through the *pectinalis* muscle, and also when made upward from the foot; pressure of the head of the femur into the acetabulum, abduction and rotation outwards, aggravate to an unbearable degree the sufferings of the patient. Movements that influence the hip *joint* merely, as well as all other movements, produce the greatest pain just in the joint.

4. *Rheumatism* may occur at any stage of life and in either sex; but there will usually be other marks of it either present or in the history of the past, and the characteristic rheumatic pains will distinctively diagnosticate this sort of hip affection.

5. *Spinal Disease*, but more particularly that form of it which arises from an accumulation of pus,—as, for instance, where an abscess results from caries of the vertebræ, but the accumulation gravitating downward through the fascia, it may and often does occupy the same situation on the pelvis as that which is occupied by the collection of pus resulting from sacro-iliac disease; but then there is tenderness over the affected portion, or the vertebra projects, or the spinal column has lost its flexibility, and now moves stiffly as a whole.

6. *Disease of the pelvic bones*, and disease of the sacro-iliac articulation, may occur entirely separate or together. The former may commence at the *crista ilii*, the *tuber ischii*, or at the *acetabulum*, which latter is the more usual seat of this disease, and then the symptoms are like ordinary coxalgia. By thus merely calling the attention, by this concise rehearsal, of young medical gentlemen to the possibility of such conditions, I trust to prevent them from falling into any serious error while treating the less or more grave nervous affections of the hip and pelvis. But, in all faithfulness, I should have mentioned one other affection that may assimilate either or all of these diseases. I refer to *the hysterical affection of the hip joint*. But here

you will be put upon your guard by the age and sex of the patient, by other manifestations of hysteria, and, more especially, by *the excessive superficial tenderness over the whole haunch, hip, and thigh, but no pain on strongly pressing the limb from the foot towards the pelvis;* besides, the hysteric-hip patient has not the worn aspect of those really diseased patients, where the cartilages are ulcerating, and thus causing the pain.

*Nephralgic pains* must be distinguished from rheumatic on the one hand, and on the other from colic pains. In lumbago there is pain in the back, and it may or may not be attended with fever; but lumbago pain usually affects both sides, and is aggravated by stooping, or any motions that call the muscles of the loins into action. It originates, frequently, in some effort or strain of which the patient is made painfully conscious at the time, and it is seldom attended with any urinary trouble.

When lumbar pains, depending upon rheumatism, extend from the back into the thigh, they mostly follow the course of the smaller and greater sciatic nerves, and are felt down the back and outer part of the limb or limbs, and are not attended with nausea or vomiting. But the pains that accompany kidney affection, as nephritis, or nephralgia, shoot rather along the track of the anterior crural nerve, down the inner side of the thigh.

*Nephralgia* is commonly, but not always, produced by the transit of a urinary calculus from the pelvis of the kidney, through the ureters, towards the bladder; *towards*, I say, for when it once reaches the bladder, the great distress is over. This process, of passing one or more little stones of urinary calculus from the kidney to the bladder is called "*a fit of the gravel.*" The symptoms are these: pain, usually very severe, but sometimes dull; usually on one side only, along the flank of the abdomen down the track of the ureter on that side, with numbness of the thigh on the same side; repeated desire to make water, which is generally high colored; and there is nausea or vomiting in proportion to the severity of the case. In the male there is retraction of the scrotum, and perhaps pain in the testicle.

*Colic* pains, we must bear in mind, may occur in those parts

of the abdomen which correspond to the place of the ureters; besides, colic is attended with nausea and vomiting; but there is no disturbance of the urinary functions, and this is a grand distinction. If the pain is truly referable to the ureters, the characteristic drawing up of the testicle, and numbness of the thigh, are sufficiently marked, when they occur; but in some cases these marks are altogether absent. In such cases the pain will often begin in the region of the kidney, on that side, and soon extend around the side to the flank of the abdomen, and so down the groin; and by this we may know that the trouble is in the ureter.

There is, besides, a kind of paroxysmal pain, and distress at and about the epigastrium and sides, that is not gastric, but is the referred sensation, diagnostic of spinal caries. In these cases, whether the disease has a traumatic origin, or is the result of vice of constitution, in a majority of them, caries of the spine is ushered in by long-continued and oft-repeated attacks of simulated gastralgia. Dr. B. Lee, of New York, says, that out of nearly a hundred cases which had come under his observation, not a half dozen failed to give the epigastric pain as the *earliest* symptom. In some few of these, the disease went on to marked deformity, without apparently otherwise affecting the general health.

This *referred* pain begins at the epigastrium, usually, and extends to the umbilicus, or in one or the other of the sides. The length of time from the first appearance of this symptom, until the ulcerative process has destroyed the bone of the back sufficiently to show actual deformity, is variable — say, from six months to one year. So that, when seeming epigastralgia occurs in a young person, is persistent, and resists the ordinary remedies, and especially if the pain be decidedly paroxysmal in character, and if otherwise unaccounted for, look out for spinal disease. It is a well-known fact, that lesions involving the great nerve-centres are expressed by abnormal sensations, or by contractions or atrophy. This is, then, simply a referred sensation.

You will never find pain in the back as an *early* sign of caries there, nor even tenderness on pressure made along the seat of disease, as might be expected. Later in this active stage of the

disease there is tenderness; but it is then too late to accomplish much. Therefore examine the spine. Dr. Lee says, "Strip the patient's back, and place him in a good light, and if you find an angle that is not a natural curve or projection, but an actual angle, it is probably the seat of the disease. Carefully scan the carriage and gait of the patient, and see if while walking the toes turn in and the body is carried slightly bent forward, as if to avoid a jar; and see also if he or she can readily bend the back, as by stooping forward to pick up a pin from the floor; for if these evidences are apparent, then there is reason to suspect incipient disease going on between some of the vertebræ."

### *Sciatica.*

Let us here examine the affections of the great *ischiatic nerve*, because they may be regarded as a *type* of local nervous diseases in general. *Sciatica*, in the first place, must be contradistinguished from simple *nervousness*, (in itself considered,) as exalted nervous function, or nervous derangement, or neuralgia, or perverted conditions, sensations, and motions. This malady takes its name from the great *sciatic* (ischiatic) nerve, which is the seat of the affection. The sciatic, which is the largest nerve of the human body outside of the brain and spinal cord, having extensive distribution of its branches, enables us to observe and study the phenomena of *nerve inflammation* and *the neuralgic condition* more definitely here than when similar affections are seated in smaller nerves. This great nerve trunk is formed, we must first observe, by the union of the terminal branches, or roots, of the lower portion of the spinal cord, (*cauda equina*,) which pass from the lumbar and sacral ganglia out of the pelvis, by the ischiatic notch, as a very large nerve cord. It then takes its course down the outer and back part of the leg to the foot. When the pain is seated in the bottom or outer edge of the foot, we know it is in the ultimate twigs of the great sciatic nerve. If the pain is chiefly in the *inner* and *anterior side* of the leg, or about the inner ankle,

then we know it is rather in the ultimate ramifications of the *crural* (femoral) nerve. (See *chart of surface nerves*; and notes on p. 460.)

Sciatica, (not sciatic neuralgia,) in its true and less frequent forms, is a real inflammatory disease, (*neuritis*,) generally seated in the nerve, or, rather, *in and about the sheath of that portion of this nerve, where it passes behind the neck of the thigh-bone after it has emerged from the pelvis*. This is explained, perhaps, from the fact that at this spot the greater sciatic is more exposed than any other large nerve trunk in the human body. It is here liable to be exposed to severe or prolonged pressure in sitting and walking; to bruising and concussion; to irritation, as from severe toil, riding and walking; to chill and congestion, from cold, wet, or damp, or from sitting upon any cold seat, particularly after great heat or fatigue; any of which is sufficient to set up a morbid action that may amount to a *neuralgia*, a *rheumatism*, or an acute attack of *sciatic* inflammation. Now, some always regard this malady as a neuralgic or rheumatic affection; and no doubt it does occasionally partake of the one or the other specific character, because of the existence of one or the other in the system at the same time. But sciatic neuralgia may appear occasionally as a mere *symptom* of some morbid irritation in the alimentary canal, or of some one of the inter-pelvic viscera, thus being only a reflex nervous action; then, after the cause is removed, the painful condition of the nerve appears to continue chronic, just as palsy of the limbs continues, after the lesion in the brain, that was the first cause of it, has been healed.

It is all important to be able to distinguish the *organic* from the *symptomatic* sciatica. In tracing the cause of each particular case, the *history* of it becomes an important *witness*, not to be slightly questioned, because of the more prominent symptoms in all cases being so similar. Nevertheless, by careful analysis of the local and of the general symptoms, and by tracing the history of the precedent circumstances that are connected with the appearance of the pain, we shall find the apparent difficulties of the diagnosis to vanish as this investigation proceeds.

The very first symptom, mark, of *acute sciatica* — which, indeed, is manifested very soon after the exposure of the patient — is a sense of weight of that leg, together with a feeling of coldness, numbness, or a want of sensibility; and this is accompanied, or perhaps *soon followed*, by rigors, and other very disagreeable general sensations, such as occur on ordinary febrile attacks. A restless, feverish, and uncomfortable night follows, after which the patient experiences a very threatening and tiresome pain in the course of the great sciatic nerve. The limb is now all but powerless, with growing pains either down the back of the thigh, (which is becoming, also, extremely tender to the touch,) or on the outside of the knee, or the calf of the leg, or near the external ankle bone, or, perhaps, involving the whole limb. If, now, the limb is moved, the pain increases, darting up into the loins, and down the limb. The patient wishes to lie on his back, with the limb extended, and complains now of the prickling sensation called "pins and needles." The attack may be more or less gradual, and the febrile phenomenon more or less great; but in any case where this affection has attained a degree of severity that characterizes the acute, the symptoms are so characteristic that no practitioner of ordinary intelligence can fail at once to recognize its true nature. But the great majority of cases that call on medical men for treatment are the sub-acute. The history and symptoms of these are the same as the acute, only less in degree and extent, and the invasion is more tame. The suffering and the lameness even here are great, and the patient finds no easy position.

In case the early stages of the acute or the sub-acute attack are not submitted to active and controlling treatment, the case is very likely to merge into the chronic form, and, as such, it may continue to harass the sufferer for any length of time. But it may be asked, Where is the line to be drawn to distinguish the acute and sub-acute from the *chronic sciatica?* The chronic disease of a nerve, says Dr. Rood, of England, differs not essentially from a similar morbid condition of other structures. The term "chronic," when applied to disease, does not indicate merely or exclusively the idea of duration, or long continuance,

as the origin of the word — *chronos*, time — would seem to imply, but, rather, *designates a special form of morbid action.* Then, observe, the symptoms of pain, tenderness, weakness, &c., will be present both in the sub-acute and in the chronic. In the former they will be intensified by exercise; in the latter, at first, diminished thereby — i. e., within certain limits. In the former, the sufferer will commence his walk feeling but little pain; but at every step it increases, and the farther he walks, the more severe it becomes. In the chronic sciatica, he feels stiff, and starts with difficulty; but, once up and off, he progresses with more and more ease after having walked a little distance, and then may even feel almost well, for a short time, being quite free from pain: but if he extends his rambles, a feeling of fatigue soon creeps on, followed by pain, and these increase. The exercise thus acting as a remedial agent *to a certain extent*, that limit passed, it becomes an irritant, and then tends, on the contrary, to aggravate the very disease upon which it had just before exercised a beneficial effect. Now, a delicate illustration of this is observed in treating an ordinary case of inflammation of the conjunctiva of the eye, which, moreover, shows the striking effects of the judicious and *skilful* use of different stimulants in the varied treatments of disease. At the very turning-point of a case of this kind, the application of an appropriate stimulant operates upon the disease "like a charm," and, for the patient, most advantageously. If the application be *delayed*, a stimulant of the same strength would prove useless, or worse than useless; to produce the desired effect, its potency would then, probably, need to be doubled. But, on the other hand, where the stimulant is applied *too soon*, — i. e., prematurely, — or if too strong, it operates then as an irritant, and rather augments the disease it was intended to cure. Exactly similar effects are produced upon the *nerves*, although hidden from view; for it is a law in therapeutics that, whether the application be direct or indirect, stimulating or soothing, the same influences may be brought to bear, and the same results obtained, upon diseased parts, wherever seated.

It is obvious that an *inflammatory* action cannot go on long,

in any structure, without producing important changes in its organization. The more active the disease, and the more delicate the tissue, the more rapidly will a healthy structure be deteriorated, and the function of the organ be deranged. But probably *the sheath of the nerve* is the primary seat of the disease in true sciatica, which becomes greatly thickened, first, by venous congestion, and, secondly, by fibrinous deposits. This thickening of the surrounding tissue causes a pressure on the fibrils of the great sciatic cord; and any lurking inflammation in the sheath of the nerve must, after a time, extend also to the medullary matter contained within it; and this may explain the coëxistence of the two opposite sensations of numbness and of pain. The latter is supposed to result from the morbidly increased sensibility of the membranous structure which usually attends inflammation; the former, from the compression of the nerve substance itself, caused by the thickened sheath.

Dr. Marshall Hall gave a graphic account of a severe case of sciatica, but a short time before his decease, which illustrates how this great nerve may be thus utterly disorganized, and its functions at first perverted, and finally destroyed. The whole limb, in that case, became useless, and wasted away, ultimately, to mere skin and bone. But this result is only occasional. In the worst cases, although lameness may persist for a long time, yet usually the sufferer ultimately regains mostly the use of the limb.

No form of electricity is found useful for acute inflammatory sciatica, unless it be actively employed within the first twelve hours after the sensation of weight, coldness, and numbness in the limb, and while the rigors and the horripilations are still inaugurating the attack. And if this does not peremptorily cut short the invasion, as it usually will do, particularly if it has been aided with ten or twenty grains of Dover's powder, thorough warm bath, and careful nursing, then the acute sciatica must be surrendered to *an active antiphlogistic treatment* by smart aperients, bleeding or leeching, antimonials, or other diaphoretics, as best adapted to the individual constitution and habits, which then must make the first chapter or "act" in the

work. The next must be tonics and ferruginous preparations, if the patient is feeble or aged; but if in the prime of life and good general health, then quinine, or Fowler's solution, or mineral acids, are indicated. If plethoric and vigorous, let a small bottle of congress water be taken every morning for a week, and repeated every alternate week. Rashness and timidity are equally to be avoided in the treatment of nervous diseases. One may push his antiphlogistic treatment so far in some slight case as to debilitate his patient unnecessarily, while in another case the same treatment would not have been severe enough to conquer. Another may err in adopting only palliatives, or mere soothing and temporary relief, where the case, on the contrary, demanded most active and prompt treatment to insure a cure. Therefore, whether the case be acute or chronic, the skill of the practitioner will be shown by the correctness of his opinion as to the seat, the nature, and intensity of the affection, and by the precision and judgment with which he selects and applies the remedial agents at his command — doing neither too little nor too much, but doing right, *and at the right time*. If he strikes a vigorous blow, he does it with just sufficient force — enough and no more — to produce the effect intended; and then he fails not to follow up the advantage gained by calling to his aid such other appliances as are found to have power to complete the restoration. These are our *general principles*, and are intended to apply as well in the treatment of any other nervous disease as for *sciatica*.

*Case of Acute Neuralgic Sciatica.* — Mrs. G., a young widow, aged thirty-four, nurse. Was called late in the evening, March 28, to a residence where she was at the time nursing a lady patient. She was a fleshy, lithesome person; had been always well; had much going up and down stairs, of which she never spared herself; said she had probably taken cold the week before, which seemed to result rapidly in this acute attack of neuralgic sciatica of the right side. Her tongue was coated, pulse 95, and she was restless, and in agonies of pain, which had been increasing all day; could neither stand nor sit; much tenderness from pressure over the sciatic nerve exit, which also caused darting pains down the limb into heel and toes.

*Treatment.* — Ordered for her *no* electricity, (contrary to her wish and expectations,) but *pilulæ duæ hydrarg., et injice sol. atropi* ♏xxx, *in lateri dolenti;* to be followed in early morning with a full dose of *sal epsom.* The 29th, had experienced immediate relief after the injection; slept well nearly all night; hip felt sore, she said, and but little pain, unless from pressure. Ordered *pulv. doveri, et quinia* ā ā gr. x. *Rept. inject. horâ somni.* The 30th, had a good night; bowels freely relieved; pulse 76; tongue with thin white fur; still some pain recurs in hip, and even down to the toes. *Inject. repetantur.* April 4. This morning the pain was entirely gone, and she appeared, and said she felt, quite well of all her pains, cold, and lameness; still I ordered a repetition of the atropine injection. In a few days she was well.

*An inveterate lameness of Hip and Leg*, usually called *chronic sciatica*, is a partial *painful-palsy.* Quite a number among the sciatic cases which have come under my own observation and treatment are of this complex nature. It is a tedious lameness, with a still more tedious pain. It seems to arise from some injury to the hip, leg, or loins, as from a strain, or cold, involving the sciatic and crural nerves in a morbid state; and probably, also, the whole sacral plexus, with its large nerves and their branches. Its character seems like a rheumatic neuralgia; but the effect of remedies leads me to the opinion that it is a traumatic, painful, partial, local palsy, from nerve injury or disease. (See p. 460.) It may partake of the double or compound character of rheumatism with a nerve injury.

These cases are frequently traceable to simply sitting on a cold seat. The stone, iron, and other seats with metallic covers, so fashionable in public grounds, are decidedly objectionable. They are, in my opinion, — indeed, to my certain knowledge they are, — producing and aggravating these results. In thin dress, and the summer time, when the person is warm, this evil result is most liable to follow sitting upon the ground or any damp or cold seat; as also from chill or dampness through thin shoes. We should caution persons, especially females, under certain circumstances, from using such seats, for sciatica and inveterate

lameness are by no means the only evils arising from sitting upon a cold, damp, or caloric-conducting seat. As a sanitary measure, such seats should be replaced by seats that are non-conductors of animal heat. For treatment, prescribe *rest*, *formulæ* 7 and 1, with electro-puncture, or the firing-iron.

*Spinal neuralgia*, spinal hyperæsthesia, spinal irritation, and back-ache, are very apt to be mistaken one for the other, or to be interpreted as evidence of disease of the spine, or of the spinal cord, or of its tunics. In very many cases, where there is a *too conscious sense of having a back*, it is merely one of the manifestations of the hysterical temperament. No doubt that, in persons of a delicate or weakly frame, the same muscular effort which is painless in the robust, is a cause of more or less permanent real aching, and this is the character of another large class of these cases; and there are those, again, that we can only refer to irritation, or hyperæsthesia, of the short nerve-branches distributed to the surface along the back, but in no sense to irritation of the spinal cord. It is a deplorable want of medical sagacity and skill to order such a patient to a supine position for months together, and obtain relief only at the cost of general stamina, where the opposite course is so clearly indicated. Give such a patient open air and sunshine, with plain food and no meat; stop stimulants and surface-friction; prescribe tonics, (as *formulæ* 2 or 12, with 34, and 35, alternated to the spine,) and then follow this up with deep-shampooing, and a down-running extra, or primary, small current of electricity; light gymnastics in the open air, or horseback riding, and she will not only obtain relief, but real constitutional sturdiness and endurance.

The cause of irritation, in doubtful cases, can be most easily proved to be of this nature, or not, by the great relief or entire disappearance of the pain, or other disagreeable or distressing sensation, upon the patient's assuming the recumbent posture; whereas if true irritation or congestion of the spinal cord exists, the pain and distress are increased by it.

Now we come to the use of *electro-therapeutics*. Here let me forestall the older and erroneous notions of "*temporary relief*"

by electricity. Dr. Rood recently said in his excellent dissertation on the subject, that sciatica "is, *as a general rule, and almost without exception, neither a gouty nor a rheumatic affection;* and I am fully persuaded," he says, "after carefully studying the subject, and watching the course and character of the malady in all its forms, that those who hope to *cure* it by a special medication, on the ground of supposing it either gouty or rheumatic, will necessarily fail in the attempt. They may keep their patient under treatment, trying this or that medicine for many months, the malady meantime fluctuating, but showing no signs of *yielding;* if recovery does take place, it will probably be at some remote date, and that perhaps after several years; the sufferer apparently being in no degree indebted for his recovery to the aid offered by the medical treatment, or liniment appliances. Such cases reflect no credit upon the healing art; yet the fault lies not so much in the art itself, as in the person who professes to apply its resources."

A patient is laboring under supposed sciatica; now, if it is truly so, whether neuralgic or inflammatory, you will find that if you press firmly near the posterior edge of the trochanter major, or near the superior spinous process of the ilium, or at the upper part of the ischiatic notch, in all probability not only will the point so pressed exhibit tenderness, and perhaps pain, but the patient will tell you that a distinct pain also shoots down the limb, and request you not to repeat it. These are the more usual results of such investigations in sciatic affections.

There is, moreover, a kind of sciatica that now and then presents, which, if not correctly understood, will be difficult to cure; for it is truly associated with *disease of the roots of the anterior crural nerve*, the more prominent symptoms of pain and impaired muscular action manifesting themselves mostly in parts to which the branches of this nerve are distributed, and at the same time the great sciatic nerve appearing to be exempt from disease, i. e., *at first*, but some time *afterwards* (mark this) giving evidence of some trouble there, particularly after any considerable or unusual amount of exercise. But when it is remembered that both the *anterior crural nerve* and the

*great sciatic nerve* receive their originating branches for their structure from the same *fourth pair* of lumbar nerves, and are, indeed, but the prolongation of the sacral ganglia, it is seen that there is a very close relation between these two great anterior and posterior nerves of the lower limb. The roots of these great nerves therefore perforate the psoas muscle, and this may account for the increase of the severity of the symptoms after walking in such cases. We may conclude that where there is *absence* of tenderness over the exit and course of the trunks of these two great nerves, and yet evident sciatica, then in all probability the seat of the disease is rather at, or near, the deep-seated *roots* of the nerves, and that the psoas muscle, as in walking, is probably the irritating agent. A large blister applied at once over the whole lumbar region in such a case, and repeated a few times, will materially aid in *preparing* for the cure. The compound iodine ointment, or tr. iodine fortis, may be substituted. But the repeated application of *direct* Galvanic or Faradaic currents will be found the most effectual means for completely clearing those deep-seated nerve roots of any remaining venous congestion, or discrasia, by catalysis.

Cases of *symptomatic* sciatica are not rare. This form of the disease arises from retained *scybala*. Having observed that in all these cases *the right leg* is the one affected, we believe that the indurated *fæces* or *scybala* are impacted in the *cæcum* and ascending colon. Dr. Hancock was the first to give this explanation of these cases. These may be *acute* and severe cases, simulating the acute form of sciatica, or they may be *chronic* and simulating the rheumatic or the true chronic sciatica. Remove the cause, then, first *by active purgatives*, as turpentine and oil, or croton oil, or colocynth pill; and then arrives the time to apply the electric current to the loins and bowels, without delay, so as to give tone where was atony. *A constipated habit must ever after be sedulously avoided, even for a day, by every such patient.* Aperient medicines are, indeed, most efficient *assistant* remedial agents in the treatment of this as well as some other forms of sciatica.

Finally, we may be satisfied that the much known and little

understood *sciatica* occurs as an *acute* disease, whose inflammatory character requires an active antiphlogistic treatment. *Sciatica*, moreover, occurs as a true *chronic* disease, where blisters, iodine, and electric currents are required to eradicate it; *sciatica* may occur as a *symptomatic* disease, and that either acute or chronic, which requires active aperient medicines, together with electric currents, to restore tone and function; *sciatica* may occur with a *rheumatic taint*, or any two or more of the foregoing forms may occur in the same case; but, after all, *it more generally occurs as a pure neuralgia*, and simply requires good electrical treatment to cure it.

Case 1. — An elderly clergyman, who had long been very subject to sciatica, of a truly neuralgic kind, having heard of my mode of treating such cases by galvano-puncture, came from a distant part of the state, last spring, for the purpose of putting himself under my care, and remaining in the city until cured. I inserted six of the four-inch gold needles, as three pairs, along the course of the great nerve trunk of the right thigh, every other day, for three times. In one week he was so well that he concluded to return home. He writes me that he has been quite well of it ever since. This was a chronic case.

Case 2. — A lady in the prime of life, residing in Dorchester, but a patient of Dr. Bartlett, of Roxbury, about forty years of age, was suffering so much from lumbago and sciatica on both sides, that she was almost helpless; and being fleshy, she could not get in or out of bed, nor even arise from her invalid chair, without assistance. She had long tried internal medicines, blisters, tincture of iodine, mustard, and cold water. I was sent for by the advice of her physician, and applied (or rather inserted) the long gold needles for electro-puncture, over the most painful parts, and used in this case a very mild primary direct current, but held steadily in contact with the silver wires in the eye of the needles, for one minute; that is, there were inserted three pairs of needles, and I made contact with two at a time, and thus occupied at each sitting some five or six minutes in all. In ten days this was repeated five times, when she walked down stairs and about the dining room, as she had not done since the winter

before. She soon recovered, and is still well, and may be seen every fair day in her carriage about our streets where ladies do trading.

Case 3. — A truckman, of middle age, applied, with a chronic neuralgic rheumatism lurking about the parts of the right shoulder, but mostly in the deltoid muscle, at its lower end where it is inserted in the humerus. The shoulder muscles and joint were so lame and painful, that he could not raise his arm, and the pains at times were most excruciating. It appeared to me a case to be most speedily benefited by electro-puncture, and I therefore inserted one needle in front and below the head of the humerus, and the other at the insertion of the deltoid, and with an *inverse* current of bearable strength, which was five Daniell's batteries; it was allowed to continue for some five minutes, with as many interruptions at every thirty seconds. He was greatly "suppled" by this one *seance*, and two more eradicated the whole "*tangle*," as he termed it, so that he swung his arm in all directions; only it was not as strong, however, as before the rheumatic attack, which was some months previous.

It can be seen, I think, that some chronic rheumatisms and chronic neuralgias may thus be cut short more surely than by any other means. No doubt simple *acu-puncture* would prove serviceable in these same selected cases; but it is my opinion, from experience with both, that every *seance* with electro-puncture strikes a more effectual blow for disturbing, or for modifying by direct catalysis, and hence changing the polarity of the morbid nerves, and therefore for eradicating the disease, than *many* acu-punctures, or blisters, or other less disturbing forces can possibly do.

In one extremely bad case of sciatica, I adopted the following plan: The patient was placed on the operating mattress, lying on his sound side, with the limb semi-flexed; placed the positive electrode, which was a soft sponge, over the most painful spot, and this was just back of the trochanter major; while the negative electrode, also a moist sponge, was firmly placed some four or five inches off, and then at every ten seconds moved along in a radius about the first electrode, so that the current

of medium strength, whether Galvanic or Faradaic, should flow in all directions *from* that centre of pain, but not removing the electrode until the pain was fairly subdued, which, however, was brought about in some six minutes. The *seance* was then finished with the steady current run *down* the limb for a minute or two from hip to ankle. When twinges of pain occurred during the *seance*, I at once took off the *upper* electrode, some two or three times, very suddenly, so as to produce twitchings of the muscles, and this scattered the new-growing pains. This treatment was repeated every other day for ten days, when all pains had vanished completely. Further treatment, but more seldom, restored the limb also from weakness and lameness, so as to be very nearly, if not quite, equal to the other.

### *Gout.*

*An attack of gout* is now, by some learned physicians, believed to consist in a primary irritation of the peripheric nerves of certain parts, and must be regarded in the light of a neurosis. It may often be observed, we know, that just before an attack there are symptoms of unaccountable nervous excitement or depression; and sometimes, or in some cases, this is quickly followed by strange sensations of weight, or pressure, or as of hot air blowing over the part, or as the crawling of insects over the surface of the nerves of a part about to be attacked. Now, if at this premonitory stage, and without delay, the affected part is smartly electrified, or else faradaized, and an active cathartic be promptly administered, followed by an anodine and tonic, the cure comes before the disease. This is the anticipating or abortive treatment of gout.

The foregoing symptoms, as the prelude to an attack of gout, was observed by Dr. Valleix, who called them *neuralgic*, as if independent and separate from the gout. The regular intermissions during an attack, with a return of aggravation at certain hours, and a peculiar nervous debility which remains in the affected part for a time, also point to a nervous character. It is shown, moreover, by the tendency to metastasis, from the

effect of certain external injurious influences, that sometimes takes place suddenly, as from strong external local applications improperly made, (*during the active stage of gout,*) relieving the part primarily affected from all pain, but producing nervous symptoms in the part secondarily affected, and that without organic changes. At all events, besides these evidences of its nervous character, the results of all experience teach us that cathartics, narcotics, and tonics cut short an attack of gout, when already too far along to be treated by the abortive process.

*Latent Gout.* — A peculiar constitutional cachexia there is, which, until it shows some specific character, is quite uncertain, but is often met with, in a class of patients, and explains numerous maladies; the causes of which seem to be otherwise unintelligible. There is a gouty diathesis, though no attack of gout has ever appeared. Such people are liable to a variety of cutaneous affections. Dr. Garrod believes that the gouty swelling itself is an erythema, not an actual inflammation in its usual sense, but a transient erythema of the cutis, attended with œdema of the sub-adjacent tissue. Hyperæsthesia is one of the most troublesome states of the skin in such persons. This may become an intolerable sense of itching, of heat, of formicans, or a sense of heat and feverishness, and may be the precursor of an attack. Or it may run into prurigo at the vulva or anus; accompanied with flatulence, anorexia, or gastrodynia, or constipation, with mental disquietude and depression. To correct these, and to eradicate the gout-poison, the promoting of uric acid urine is the quickest relief.

*Tophaceous Deposits.* — These are found, in some of gouty constitution, in the vicinity of small joints, and sometimes on the helix of the ear, as first pointed out by Dr. Garrod. These deposits consist of the urate of soda, and vary in consistency from a semi-fluid to a solid state. When seen on the ear, they are white, and about the size of a pin's head, or larger; the ear being sometimes also erythematous, and injected with blood. The ears, in short, are liable to gouty attacks, like the nose.

In *atonic gout*, or that condition which we find after the fever and inflammation of an attack have subsided, not only in regular

inflammatory gout, but also in those masked cases of wandering or *radiating* gouty pains, electricity, when correctly applied, is of untold value, for it not only relieves, but it breaks up, *the pain-causing condition*, whatever that may be; so is this true of it in *gouty*, as well as rheumatic, *nodosities*, and in the wandering or flying pains of rheumatic gout. Moreover, we often find, during the stages of *arthritis nodosa*, that the epiphysis of phosphates or bony deposit and pseudo nodosities recede, after a time, particularly if about the shoulder joint, leaving an extremely sick and weak state of the neighboring muscles of the shoulder and arm, which, if not promptly treated, soon become soft and lean, the flexors taking on a condition of tonic contraction and hardness, while the extensors yield to the perpetual traction, and assume a state of partial wasting paralysis. Now, by a skilful use of electricity, this evil may be averted, and even a more or less restoration may be obtained where it already exists.

The treatment of such cases may be successfully conducted by means of either primary or secondary currents; but here I have found that the alternate use, first of electro-magnetism, and then galvanism, at each *seance*, or, rather, the first few days the former, and then the latter for a few times, to give the best results. The induced current must be employed with the least possible catalytical power, i. e., with the zinc lifted as much out of the battery solution as possible to allow the machine to work; and *this* removes the more urgent or prominent *symptoms* of pain and stiffness most readily, and, at the same time, seems to prepare the thus conditioned tissues for the better and more thorough in-working primary current of galvanism, — say, from twenty to thirty Daniell's elements subsequently brought to bear for eradicating, as it were, the dregs of the disease, — that discrasia that seems to be so prone to remain and act as a nucleus for a more ready or easy return of the complaint from slight causes. In fact, this should be kept constantly in mind while treating this class of painful maladies, as it so greatly determines the future condition of the patient. Whatever method or current is used, close each seance by faradaizing all the region well, through the wire brush.

As a *rule* to guide us as to how long we must wait for the fever and active inflammation to be put out or subside, I find that the larger are the bones and joints which are the seat of the affection, the more boldly we may venture to proceed with our electric treatments; but this not to the exclusion of other means indicated, nor yet neglecting the regimen.

Another *rule* I have also adopted, for being on the safe side, at least, until we know more, and that is, never disturb *old gouty cases* (as we are often solicited to do) while they remain at ease from pain and swelling, but the instant the pain appears, be notified, and that very hour attack it, and never leave until it is subdued and quiet again, and so hold it in check by daily watching and vigilance. But if not so fortunate, if the call is later, or by any means the fever and local inflammation have fairly set in and rage, then other influences must be relied upon until the proper condition is arrived at, that admits of the attempt of the catalytical in-working of the primary current of galvanism.

### *Rheumatism.*

*Acute rheumatism* usually comes on with the ordinary symptoms of fever; soon after which, or at the same time, or sometimes even before the appearance of fever, excruciating pains are felt in different parts of the body, particularly in the larger joints, which become more or less red, swollen, and stiff; the pain shifting from one to the other, at times, with great rapidity. It naturally runs six weeks. One of the peculiar symptoms is, a profuse perspiration over a very hot skin, without affording any relief. The only danger to be apprehended from acute rheumatism is, the translation or extension of the disease to some internal part, particularly the heart; and this tendency must always be borne in mind. After a few weeks the disease usually goes off, but leaves the patient very liable to a recurrence from slight exposures, or from errors of diet. Now and then this affection takes on more the appearance of gout, and seems to be a complication. It is then termed *gouty arthritic*

*rheumatism*, or *rheumatic gout*. Acute rheumatism may or may not terminate in the chronic.

In acute cases, if early seen, — that is, for attacks of rheumatism or gout, — I prescribe *formulæ* No. 3 and 5 ; electricity never. The excruciating pains and paroxysms usually yield in two or three days, and the attack subsides entirely in a day or two more.

*Rheumatic Fever.* — When I was in general practice, and had the care of such cases, I usually commenced the treatment from the first, as soon as the bowels were open, with quinine in one or two grain doses, and iodide of potassium in five grain doses, each given every six hours; that is, three hours apart. To relieve pain and secure rest, it is necessary to provide some opium pills, to be given as required.

Dr. Gordon, of this city, says he treats an attack of acute rheumatism in the following manner: "After having procured free evacuations by means of senna and salts, I begin the administration of equal parts of vin colchici and spirits terebinth, in ten-drop doses, every two or three hours. Then, after a day or two, I give, in connection with the just-named prescription, (but only at longer intervals, say of six hours each,) tinct. ferri chlor., ten drops, using as much opium as necessary to quiet pain. I also allow a free use of good coffee, that is of average strength. If the appetite remains, the patient is allowed a moderate use of his usual food, at the usual meal time."

The author has found the above admirably adapted to some cases, while in others, — i. e., for abbreviating the discouraging *duration* of acute articular or periosteal rheumatisms, — the administration of large doses of iodide of potassium, with a sufficient quantity of sulphate of morphia to control the outrageous pain, proves to be the better means. Give, in the course of the day, from ten grains to half a drachm of the iodide, with, say one half, to one and a half grain of morphia. Bathe the joints and painful parts in a lotion of the cyanuret of potassium, or soap liniment with opium or New England rum, then cover with water dressing, and all well covered with dry flannels.

*Acute inflammatory rheumatism*, during its early and most active stage, calls for the alkali, nitrate of potassa. It is here surely and excellently adapted. Ten grains given every two hours, dissolved in a cup, or part of a cup, of gruel, to be repeated six or eight times a day, and to be persevered in for only two or three days. In the more severe cases, or stronger constitutions, we may order half an ounce or an ounce to be dissolved in a quart or two of gruel of corn or oat meal; all to be taken, by half cupfuls at a time, during the twenty-four hours. Give opium or morphine at night for sleep, or even every four or six hours if necessary to keep down pain.

Watch the action of the heart daily by means of the stethoscope. This, in these cases, I never neglect. Do not trust the pulse at the wrist for judging of the failing power. A pulse may feel moderately full and soft, while the impulse of the heart has already become imperceptible, the vital energies already failing, and, if not timely supported, will speedily succumb. In another case, by examinations of the pulse and heart, we may find the former very small and compressible, and yet the impulse of the heart be good, and the sounds clear and distinct. No stimulants are here required. But quickly observe that the failing temperature of the skin, a flagging of the heart, a tongue becoming very red and dry, confusion of thought, and incoherency, are suggestive of failing vitality and the necessity of *immediate* change of treatment. Now, no more of the alkali or opium, but a liberal allowance of nourishment, quinine, and stimuli, which are to be graduated by the pulse, aided by the sounds and impulses of the heart.

But if a murmur, especially an endocardial murmur, is discovered at the apex of the heart, arising in the course of any acute or inflammatory rheumatism, however treated,—if, coincidently with its commencement, pain also occurs in the chest, the pulse becomes irregular and fluttering, the action of the heart turbulent, and the countenance anxious,—it is time for the special treatment, and it is impossible to resort to it too soon, or to push it too rapidly. Blisters large and frequent, perhaps preceded by leeches, and alkalies or iodide of potassium internally,

with absolute rest, and the semi-horizontal posture of the patient on a good couch, in a quiet place and evenly warm atmosphere, are to be put into speedy and exact execution.

The preventive influence of alkalies, over the heart, in every acute rheumatism, was first pointed out by Dr. H. W. Fuller, of England. His plan is to induce alkalinity of the urine as early and speedily as possible when first called to these cases. Then this state is to be watched for by test-paper; and when obtained, the dose is to be greatly diminished. To be of any service, the alkali must be pushed rapidly to the fulfilment of the object, and then moderately maintained. To this end, two drachms of some alkaline carbonate, or its salts, well dilute, are to be repeated every three or four hours. If a few grains of citric acid are added to each dose, just at the moment of its being swallowed, to produce effervescence, the medicine is more acceptable. I employ bicarbonate of soda and bicarbonate of potassa, equal parts. The bowels should be kept free, especially after the alkalinity of the urine is found perceptible by test; and this is to be followed for three or four days. Then give quinine in solution with aromatic tincture of bark, and the recovery of such a case will be good and clear.

We can show that actual *heart disease* is not necessarily a fatal disease in itself; but it may, and does often, produce renal disease of which the patient may die. When examining the heart sounds, if we hear a reduplication of the first or second sound, or the so-called "*cantering sound*," we may suspect kidney disease or some renal affection. We must, in this case also, be apprehensive of apoplexy. Yet such a patient can live for many years, *provided* he lives always moderately, systematically, and without pressure of business or care.

When the rash of *scarlet fever* is disappearing, in many instances I have noticed swelling of the larger joints to supervene, with pain closely simulating the local effect of sub-acute rheumatism. It may be rheumatic, for occasionally the heart is also affected; and it may be owing to the retention of some poisonous excrement in the blood. At all events, no treatment is so beneficial as the moderate use of electricity. Gentle currents

passed from soft sponge electrodes through such joints for three to five or ten minutes continuously, that is, without interruption, will start the effusion. Follow this, each time, with *gentle* handling, (*deep-shampooing*,) and repeat it morning and evening.

*The Hypodermic Injection.* — This is a nice little operation, that requires *care* in the choice of cases, as also adroitness in the performance. The greatest danger is in giving too large a dose for the case, or in putting the dose into a capillary vein instead of the cellular or muscular tissue. The accident has repeatedly occurred, according to reports abroad; but this danger is not great if we work adroitly and *slowly*. Introduce but half the intended quantity, and wait a half-minute; if symptoms of alarm appear, draw back into the syringe all possible, and remove it; but if there be no reason for alarm, finish the injection, and then immediately remove the syringe. There is no danger from repetitions, with hours or days between. Thus it becomes a very valuable resort in cases of *extreme suffering*, as electricity is for other appropriate cases. The following may illustrate: —

*Case.* — G. W., aged forty; keeper of a large livery stable; hence exposed to wet and cold air, from constantly wide-open doors. Had an acute attack of rheumatism in the latter part of October, some five months previous, when he was very sick for several weeks; had recovered very slowly, and but partially; or rather the acute affection was transformed gradually into the condition he was in when I first saw him, on the 23d of the following March. All his fever and other acute symptoms were gone; but he was still greatly afflicted, and sought me for electric treatment.

Found him only able to move a little on crutches; very lame, emaciated, feeble, and with night sweats; a *hot*, swelled knee, and tender hip; the hamstrings contracted; the knee bent and fixed, apparently immovable; the foot drawn up, and the whole in a state of *touch-me-not*. His nights had been horrible, from the agonizing pains. But there was no evidence, though some suspicions, of hip disease — the size and shape remaining quite natural, though soft, and the muscles flabby, shrunk, and sore to the handling. Ordered him generous diet and quiet, with prescriptions

Nos. 8 and 3; and the aromatic elix. vit. three times a day; valerian and acetate opii at bedtime. My object was to prepare him for the *refrigerating treatment;* but he was so feeble, and in so much suffering, that this could not be waited for; so after two days more I injected twenty drops of solution of acetate of morphine into the hip at bedtime.

This acted like a charm. He slept all night — a thing he had not done, he said, for all winter. But the pain returned during the following day as severe as ever, but not so constant; there was also some considerable nausea.

March 27. Injected ten drops of solution of atropine over the *tensor vaginæ femoris* muscle, where he seemed to suffer much pain; continued the good diet, tonic medicine, and quiet, with recumbency.

March 28. Slept well all night; no nausea, but considerable lassitude; pain, sensitiveness, and soreness wonderfully diminished; the knee quite movable, and the limb could be handled. Continued treatment.

April 2. The pain in hip and leg was almost entirely gone at all hours, day and night; the pains across the loins quite gone, and the knee less red, and less swollen. Ordered iodide of potassium, and *formula* 7, in place of the tonic mixture and nervine.

April 5. The pains are entirely gone; not much tenderness, or soreness, remaining; limb can be extended; only some drawing in the gracilis and inner hamstrings. Continued the same treatment.

April 10. Patient has had no sort of pain since the last visit; the contractions are quite relaxed, the knee is nearly natural in appearance; the whole haunch and limb bear handling, so that I ordered my process of *mellowing* and *deep-shampooing*, twice a day; to return to tonic prescription in the place of the iodides for one week.

April 17. The patient said he was well; walked without a cane; the limb still some swollen, and weaker than the other. Ordered him to call for electric treatments every other day.

Electrified the extensor muscles of thigh and leg, through sponge electrodes. He soon recovered completely.

To sum up the comparisons, then, we see in *acute* rheumatism, the general symptoms are evidence of the presence of a febrile or inflammatory disorder; the sensations of the patient are *pain*. Our first object should be to learn whether the pain is rheumatic; i. e., is felt in the back and limbs, as "pain in the bones," so common in fevers; or whether it is in some defined situation, as local inflammation; or is confined to the joints. If the patient describes it as being in succession, flying first in one joint, and then in another worse, we may be sure it is acute rheumatism. If so, the pain is severe, but not coming in twinges, nor accompanied with startings, (muscular spasms,) but is continuous, and is aggravated by motion; will not bear pressure; even the weight of the bedclothes cannot be borne; every posture alike is uneasy; so the patient is still, though most desirous to move. The urine is usually more acid, and the perspiration is profuse, and it has a sour and rancid smell.

In *sub*-acute rheumatism we see no essential difference from the acute, except in intensity; not so much fever, less inflammation of the joints, fewer joints affected; sometimes it is limited to a single limb, or a single joint; and then it is apt to be mistaken for simple inflammation of the joint, or synovitis. In some cases the fibrous structure around the joint, in others the synovial membrane, is the seat of the local inflammatory action. In acute rheumatism these two are more blended; in the sub-acute we can easily distinguish the thickening of the ligamentous structures, which are firm and resisting, from the puffy elasticity and feeling of fluctuation caused by the pressure of fluid in the cavity of the joint. The first is more frequently found in the smaller joints of the wrist and fingers; the other by far the most frequently in the knee. In some cases the knee joint is affected with absolute thickening and degeneration of the synovial membrane, yet the external aspect closely resembles those from the presence of fluid in synovial rheumatism; but the cases of thickening and degeneration are almost painless throughout, and have a history, like most *joint diseases*, of general obscurity,

and extended over a long period; and there is absence of fluctuation. (See joint affections in chapter of *surgery*.)

*Muscular rheumatism* is characterized by pains and stiffness in the affected muscles, which may occur with or without attending fever. We cannot strictly call it chronic, but, in a diagnostic point of view, we recognize the existence of pain, more or less constant; aggravated, or only called into existence by muscular movements. *Lumbago* and loin pains are very frequently of this nature; which see.

*Chronic rheumatism* is attended with pains in the hips, shoulders, knees, ankles, and other large joints, but *without fever*. The pains are at times confined to one joint; at others, they shift from one to another, but *without* being attended with inflammation or fever. There is no danger attending it, for in this manner the complaint usually goes on for a great length of time, and then perhaps goes off. But the patient may become very lame in the mean time, and is always liable to have more painful spells, caused by strain, over-work, or exposure; or recurring without any apparent cause.

Neither acute nor chronic rheumatism is likely to terminate in suppuration; but a rheumatism may be complicated with scrofula, and thus result in suppuration. Yet both forms of rheumatism, acute and chronic, may be followed by effusion of coagulable lymph; which, in my experience, is quite apt to occur, so as to occasion persistent pains and permanent thickening of the part. This is not confined to the joints, but often occurs, for instance, at the insertion of the deltoid into the humerus, or where there is any tough fascia. I do not here refer to chalky deposits, but to those slightly-thickened and chronically-painful spots about the shoulders, ribs, limbs and joints, which attend, or rather follow, a slight attack of rheumatism; which itself was the result of over-fatigue or a slight injury. I believe, also, that many of those indefinite, but painful and troublesome, bunches formed in the flesh so as to involve nerve-cords, and are often called *neuroma*, are simply of this nature, and are also curable, most readily and surely, by electro-puncture, combined with the internal use of iodide of potassium, and the biniodide of mercury.

*Sub-acute rheumatism*, as well as the chronic, — many an attack of it, no matter how severe, if little or no fever, — may be cured by electricity. It alone can do it, and do it speedily and effectually. This may seem like a bold statement, especially from me, because, for very many years, I have practised and taught otherwise. Assuming, heretofore, as I was educated to believe, that an attack of sub-acute rheumatism was an inflammation, similar to other inflammatory affections, only modified by a *something* that is to be eliminated by the kidneys, I placed it in this category, and excluded all these cases even from the trial of the electric treatment. But when we recollect that an acute rheumatism (especially if with little or no fever) is *unlike* any other deep inflammatory action, — having no tendency to run into suppuration, but a decided tendency to deposit *indurations*, as the result of its effusion, — it is only a wonder we did not see the adaptation of electricity to the cure of it long before. Nor was this discovered by me. The writings of Robert Froriep, of Berlin, Prussia, and of Richard M. Lawrence, of London, first set me right on this subject; and for the past few years I have clinically demonstrated the accuracy of their findings. With Froriep this view of rheumatic affections originated.

It is also generally stated by writers on rheumatism, that acute rheumatism is *not* prone to run into or leave behind it the chronic form. But this, I find, is not true of our people. Here in New England, at least, *acute and sub-acute rheumatism often do run into, or have a sequel of, the chronic form;* shifting from place to place in one case, or settling in one or more parts in another, and thus *is prone to recur* from sub-acute inflammatory attacks. Rheumatic effusions and *indurations* attend or follow these attacks, producing a variety of chronic rheumatic muscular and arthritic difficulties; and also, or in some cases, where nerves are involved in the induration, producing hyperæsthesia, anæsthesia, paralysis, chronic or tonic spasms, an insufferable *burning pain*, and atrophy — simulating neuralgia and other more grave nervous affections of the great centres. Rheumatic effusion, in all this variety of cases, is the diagnostic sign.

*As diagnosis* of rheumatic induration by means of electricity,

I would mention first, that *the parts where effusion exists*, are not painful, when touched by handling; but their *sensibility* is even sometimes decreased, though oftener increased above natural, and this still more marked under the application of a faradaic current; that is, the natural sensibility of the skin, for the most part, is blunted to the external touch, which is often felt as a pressure, but is hyperæsthetic under electricity, and is very susceptible to atmospheric changes, as evinced by pains and stiffness. The color of these places, when it is in the skin, or just beneath it, is somewhat lighter, or whitish, which marks the outline of the effusion very distinctly. A fold of this skin, when pinched up, feels thick and smooth, and has a shining appearance. If we apply a very strong current on any part in the neighborhood of these spots, through sponge electrodes, goose-skin (*cutis anserina, horrida cutis*) is produced every where, except where there is induration, which remains quite smooth. This is most striking when, after and by the treatments the effusion has somewhat decreased, the roughness or goose-skin may be seen encroaching on the former smooth surface in stripes or spots very peculiar. These smooth spots gradually disappear, and with them the difficulty, except where deeper-seated structures are implicated — which we must now investigate.

How very interesting the fact, that the discovery of rheumatic *induration*, in doubtful cases, may thus surely diagnose acute or chronic rheumatism, notwithstanding the nerves and other variegated phenomena so well calculated to mislead us! Electricity is the best means for diagnosis, and it is the most powerful means for the cure. Its best *aids* are iodide of potassium, internal and external, hot baths, and covering the part with oiled silk. To succeed most rapidly the patient should have warm clothing, occupy a uniformly warm, dry room, observe cleanliness, and avoid exposure to damp and cold. The applications of electricity should be directed to and through the affected part very smartly for five, ten, or fifteen minutes daily, or every other day, using first the sponge electrodes, and then exchanging one of them for a metallic ball, button, or wire brush, for faradaization. To thus finish each seance, by painting-movements with the wire-brush electrode, is my usual method.

*Acute or Sub-acute Rheumatism of the Shoulders and Arms cured by Electricity alone.* — Case of Mrs. G. — Twenty-seven years of age, a delicate lady of nervous temperament, fair skin, black eyes and hair, tall and round proportions; had been subject for many years to attacks of rheumatism with fever which would lay her up for several weeks or months each time. Once it terminated in a chronic rheumatic affection, with partial palsy, which she got rid of finally by going to St. Catherine's, Canada, and bathing in that *hot salt water*, and taking a thorough treatment under Dr. Mack.

In March last she was exposed to damp and cold while travelling home from Washington, and immediately was attacked again, suffering for three days as bad as in her very worst attacks previously. I was sent for to meet her physician in consultation *as to the propriety* of trying to get more speedy relief by electricity; as he was decidedly opposed to it, while husband and friends wished it applied. He very frankly and kindly offered to give the case up to me, if I would take charge of it; but he would not give his consent to yield it into the hands of an uneducated "electrician." I as frankly stated the doubt, the attack being so acute, whether there was not too much fever, and too much time, or not time enough, already elapsed since the attack, for the faradaic current to be borne, or to succeed; but would try it for a day or two. The patient was partially under the influence of opiates, was in great distress, and in extreme nervous excitement.

I found the neck stiff, and the skin could not be pinched up; numbness and darting pains in the hand, arm, and shoulder, and her nights were terrible to her, for there was no such thing as lying down. She moaned and groaned the hours away in restlessness, and attempts to find some more easy posture. I found the shoulders, on the top and down the front of the arms, very red, swollen, and tender to touch or handle; on the back of the shoulders and outside of the upper arms there were marked indurations in the cellular tissue, which were very perceptible. The skin all along over these parts was of a shining bluish-red, while the region on the bosom, arm, neck, and back, was bright

red. Some of this redness was due, doubtless, to the liniment and fomentations that had been applied.

*Treatment.* — The positive sponge electrode was planted at the back of the neck; and beginning very gently, with the negative I first bathed the neck; and then one shoulder and arm, and then the other: landing the negative on the back of the hand, I allowed the current to run down the arm for five minutes, all she could bear, working the positive along down to the wrist; then down the other in like manner. This at first pained her very much, but as soon as the treatment closed, she was entirely relieved of pain, which returned only after some hours, and then in much less degree. Ordered *oiled silk,* but no medicine, no friction, and quiet as possible.

The color of the induration over the shoulders and upper arms during and immediately after the application of electricity was mottled; here and there were pale places, with regions of dark-red, and others of a more diffused light-red. The applications were made daily, and these spots, or "*patchwork,*" as the nurse termed them, became less and less at every treatment. After the fifth day, I finished each seance by faradaizing the whole affected neck, shoulders, and arms, through the wire brush, by painting or brushing manœuvres, and this more rapidly hastened the resolution. In ten days she was able to go out and drive to Brookline, and about daily. In three weeks she was quite well; having taken no anodines, no medicine whatever.

*Rheumatic Indurations* are very frequently met with, though I fear not always recognized; but they have so much to do with a wide range of "*chronic ailments,*" and are so seriously damaging, that we ought to be on the special lookout for them, even in seeming brain or spinal palsy. We must be prepared to find rheumatic affections, under very various forms, as those of *pain,* as perverted or diminished sensation; as convulsions and spasms; as ruinous conglomeration of tissues, contractions, and rigidities; as trembling of muscles or muscle fibres, or of whole limbs; *as swellings,* and as atrophy; as stiffening of muscles, or as partial and even complete paralysis. I could fill a volume as large as this entire work with the variety of these cases alone here treated,

but each case would only show one of an endless variety of combinations of symptoms. These cases are so well marked, when we once learn the mark, that they may most usually be recognized by sight, touch, history, and the aid of electricity, either pure, or even when complicated, as they frequently are.

Rheumatic effusions are found mostly in the cellular tissue, and frequently in the sub-cutaneous; but also in the very *cutis vera*, or true skin; are very often found in the cellular tissue of the muscles; also beneath the sheath of muscles and tendons —beneath any aponeuroses; and into or beneath the periosteum of bones, and even in serous membranes. When in the skin, the sensibility is diminished, benumbed, and yet painful, but not to the touch; the skin is much thicker, and can only be pinched up in a thick fold, and feels almost cartilaginous, or as a sensible toughness; appears tumid and smooth, and has a lighter or dirty white color, and though very sensitive to faradaizing with the wire-brush or metal electrode, there is here no rash or redness produced by it; but when this is produced, the disease begins to yield, the absorbents act, the pain is less, the motions are freer, and the recovery is actually begun.

When a rheumatic *induration* is in the sub-cutaneous cellular tissue, it is usually found either in small defined spots, or spread over a part or whole of a limb, or over half or the whole body. Upon examining the swelling by handling and feeling with the fingers, it will be found firm, feeling much like a small mammary gland, with clearly defined margins; when over an entire limb, the skin is tense, smooth, and shining, and full of indentations, and benumbed rather than painful to the handling. Where extensive or of long standing, the skin is of a bluish-red color; is cool, and sometimes only stiff; no pain.

*When the effusion involves nerve cords, there is always very much pain;* radiating below it as a neuralgia, above it as a profound ache and distress. This form of it frequently follows an attack of acute rheumatism, affecting different parts of the body and limbs, especially the shoulder and upper arm; followed by chronic rheumatic pains, and wasting, which continue for years; gradually depriving the patient of the use of his limbs, or the

privilege of sleeping a night's rest. Faradaic electricity through the wire brush, is most marvellous in its remedial effect on these obstinate cases; oiled silk or thin rubber should cover the part. Then why turn such cases loose to wander from empiric to quack, when they can be so understandingly, skilfully, and successfully treated by their own regular medical attendant?

*Rheumatic effusion and induration* have a tendency to paralysis. When the rheumatic induration has taken possession of a bundle of muscles, the whole are hard and stiff; but finally they become atrophied, and feel as if adherent to the bone; for they cannot be moved in places. Muscular indurations are usually insensible; but occasionally there are places which, when pressed, are painful, and feel as if there was a sore deep down beneath the skin. This is attended with loss of flexor and extensor power, arising not from pain, but from diminished contractility of the muscle fibres. If in these cases we apply a very strong faradaic current, and try to contract these muscles, we shall find but little or no reaction when there is much rheumatic effusion; but earlier in the same case, pain is thus produced, as also muscle response. Passive motion is possible even in the older cases, but is apt to be attended, or to be followed, by acute pain brought on in the joints and other parts.

The functions of the muscles are impaired in degrees varying from mere stiffness, to the entire loss of all voluntary motion; while passive motion is possible, but painful. Voluntary movement, after being at rest, is attended with a stiffness, and a disagreeable sensation of weight, and sometimes with tremblings, and not unfrequently with lancinating pains, which, with the tremblings, seem to be increased by change of weather. The rheumatism has weakened or destroyed the balance of power between the antagonizing muscles; hence the trembling. But this damaging will go on, and then we see partial and *painful palsy*, (which I so designate, or as the inveterate lameness,) or absolute palsy, and perhaps degeneration and atrophy. In bad cases, when all the muscles are implicated, by a slow, protracted process, there results complete paralysis, with contraction or rigidity of the affected limb, and now there may be no pain.

The characteristics of this effusion in the muscles are indurations of the cellular tissue, producing a pale, cold, hard swelling, sometimes called a "*white swelling*," over which the skin is stretched and shining, and sometimes showing very prominent veins. When about the joints, and on the back of the hand, and on the top of the foot, the swellings are puffy, thicker or deeper, more dropsical, *more of a bluish-red color*, and pit on pressure. Now and then a case is unattended with pain, but these are exceptions; but even where there is pain in or about the affected part, there is also a sensation of coldness, and an actual decrease of temperature.

*Occipital pains and distress from rheumatic neuralgia, caused by indurations, or rheumatic neuroma, involving the occipital nerves, sometimes result in painful-partial-palsy;* then it involves the motor and mental functions, and the mental and motor functions exasperate it.

Very many such puzzling, perplexing, and unyielding cases have I had (at different stages) under treatment, and I believe I now understand them. Indeed, I am prepared to say at once, that this is simply the result of that compound, or double damaging affection of rheumatism and neuralgia, caused by *indurations* involving the occipital fascia and nerves; and which, in the case I am about to report, passed not only through the different stages, but spread so as to involve the right shoulder, arm, and hand. In most of these cases, however, it is limited to the back of the head, or even to only one of the occipital nerves; or else to the axillary plexus, or the circumflex nerve, involving only the deltoid, or the whole shoulder, arm, and hand. The case reported here, I extract from my case book, the notes of which are not so remarkable as some, but give about as correct an idea of the character and progress of this insidious, inveterate, intermitting or remitting lameness, (*the painful palsy*,) as I can now call to recollection.

*Case of Professor P.*, connected with one of our universities of learning, forty-seven years of age, of medium height, size, and condition; square built, good head, with remarkable powers, and of a nervo-bilious temperament; rather inclined to flesh, but

always well; had been for a long time a hard mental worker and a great writer; with perhaps too little recreation and physical exercise; but for years, though in health, had sometimes had pains or stiffness in the back; after that, he said, for the space of several later years, he had been annoyed at times with a more dragging, tiring pain across the kidneys, sometimes in the hips, or in the shoulder, or thumb. In 1860 he was attacked with what he called "a cold in the legs," evidently a muscular rheumatism, so that he could not bend the hips or legs enough to sit down. It was more stiffness than pain, and in a few days his medical attendant was able to throw it off; not entirely, however, for he said he felt some of it at times all that winter.

In the spring of that year, after much excitement, public speaking, and exposure, and fatigue in travelling long routes by railroad, he was attacked with a very disagreeable sensation of pressure or grasping tightness over the back of the head. He was depressed in spirits, and incapacitated. For this he took medical advice and treatment for a long time; was leeched, cupped, sweated, bathed, and blistered, but to no good result. There were gradually added, in place of the very disagreeable and bewildering and stiffening sensations in the back of the head extending from neck to crown, some spraying or flashing *pains*, that were alternately throbbing, dragging, and shooting, but never ceasing. He took colchicum, quinine, alkalies, anodines, and iodines internal and external, and a great variety of baths, besides the kind offices of "*mediums*" and spiritual doctors; he tried movement-cure, hydropathy, and travelling. All failing him, and now being in a most miserable state of unrest, day and night, he had the hypodermic injection of morphine. This was a complete success for a few hours at a time, and then it was repeated. After a while the morphine was replaced by atropine. Thus, sometimes better, sometimes worse, he whiled away nine months more. In this manner he had now worked, worried, and suffered, for nearly three years, and he became impressed with the belief that the treatments made him worse.

At this stage, Drs. Brown-Sequard and Wyman, of Cambridge, sent the patient to me for electric treatment. After hearing his

story, he was examined by aid of galvanism, faradaic electricity, and the æsthesiometer, as also by the effects of ice, hot water, and the needles. No brain disease, no spinal or reflex affection could be discovered; but I thought I fairly made out in diagnosis the rheumatic history and character, and the actual visible signs of *induration*. He was frankly told that he could recover completely by a little patience and perseverance in the daily or every other day's use of *electricity* and other aids. But he was in a state of mind not to believe, as he said, because of his very extensive experience in treatments that ought to have cured him; and the fact, also, that mental work always made it worse. He would not, did not receive the electric treatments, for he was fully possessed with the belief, moreover, that his was some insidious "brain disease," because original composition invariably aggravated it; and this had been confirmed in his own mind, by a very highly respectable medical gentleman making a similar diagnosis; and another having said he thought there was a congestion of the cerebellum; another counsellor thought there was red softening, (*ramollissement*,) and he was treated accordingly each time in long stages.

On the whole he seemed to lose. He became dyspeptic (or more so) and almost hypochondriacal; constantly repeating, in a wonder, that nothing could obtain for him any release from his excruciating and maddening sufferings, as he was never more than temporarily relieved, and that for only a few hours at a time; but for whole days in less degree.

Finally the agony of his sufferings obliged him to relinquish every mental and bodily occupation. He took leave of absence to visit Europe for a year or so, for travelling, and to consult leading medical men there, and probably to get the water of the spas, and the medicated baths of France, Germany, or Bohemia. At this time, from the account, he had become, through insomnia, suffering, and dread, quite a dyspeptic, as also a general neuralgic; any derangement of his stomach or bowels, any effort of body, or worry of mind, or fret of the body, as tight boots, windy weather, or the least exposure to a cold or chilly air while the back of the neck or head was exposed, would aggra-

vate the distress in the occiput, or bring on a fresh and more violent attack. The pains now began to flash up from the cervical spine to the top of the head, and he seemed to have no fortitude left to endure it; his mental wreck was as manifest as his physical.

Early in the year 1865 he returned to his American home, but so changed! — thinner in flesh, gray, and appearing ten or twenty years older, with less pain, it is true, but almost paralyzed in his neck and right shoulder. Now, all things failing him, and all the more because of some hints while abroad, as soon as home he came directly to me, to put himself under my care, if now I would undertake for him. Said he would try to muster courage to bear any thing I might do or require of him, if I still thought there was any chance for the peculiar effects of electricity to benefit him.

By a new and careful examination, I now found he had also lost the use of his right arm; and which also caused him more nightly distress than the occiput. There was a shaking of the head, and a trembling of the right hand, that rendered the appearance of a shaking palsy. This all had come on since last spring, while in Italy; and since that, he scarcely had power to hold up his head only for a few minutes at a time; to aid this he wore a head support.

Upon stripping his shoulders and thorax, I found the right pectoral muscle, and the right arm down to the elbow, but half the size of the left; and there was a pale smooth swelling on the anterior of the sick shoulder which was painful on pressure, and caused dartings down to the little finger and its fellow; on the outer and back part of the arm all along from the spine of the scapula to the external condyle of the humerus, near the elbow, it was indurated very much, and such suffering was felt in the shoulder blade, the ear, and all along the dorsal aspect of arm and hand, but especially about the insertion of the lower end of the deltoid, as to oblige the patient to walk his room much of the time, especially nights, instead of lying down to rest and sleep. On the back of the deltoid, and so down, there was a baggy enlargement, that was surrounded by loose, flabby tissue,

and over which there was a sensation as of cold water trickling down it, and with it pains streaking down to the hand and fingers. The back of the hand, the whole of it, was swelled, cold, and sometimes puffy, and of a bluish-red color, as also were the two painful fingers; the shoulder was two inches lower than the other, and he could not, nor would not, allow his hand to be moved out sidewise from his body but a few inches, because of the stiffness, weakness, and suffering. There were deafness and roaring in the ear on that side, and the muscles of the neck were soft, though plump, while those of the shoulder and arm above the elbow were atrophied. Not so much pain of late in the occipital region, but still considerable; and there was about the neck, evidently, fatty degeneration in much of the muscle tissue inserted in the base of the skull, as there was marked plumpness with softness and extreme weakness, but with prompt muscle contraction response to the electric current.

I view the case as purely and simply rheumatic in its origin, and that not the mental labor, or the original composition in itself, was so much the predisposing or provoking cause, *as the fatigue of protracted posture, and subsequently taking cold.* My explanation was this. For writing original composition, the professor had spent much of his time, for many hours together leaning forward over his desk, with the weight of the head held or supported only by the muscles of the back of the neck, which were thus taxed for years, and became chronically fatigued. In a well man, a night's rest restores such fatigue if not too severe; but in this case, probably, while in the cars, or somewhere, he was exposed to chilly air, which set up a rheumatism in the muscles and fascia of the neck, and the induration happening to involve the occipital nerves was but the consequence; the same was probably the case with the fatigued right hand, arm, and shoulder, predisposing them to the extension of the rheumatism into those parts; for I am inclined to believe this to be generally a law of rheumatic election; that is, settling in the weakest part.

*Treatment.* — The following plan was adopted for him. He was to visit my rooms daily for a month, excepting Sundays and

very stormy weather. I began the treatment with the faradaic current very weak, directed to the muscles of the neck, shoulder, and arm, through large sponge electrodes; (the state of his nervous system and the nearness of the brain prevented me from using galvanism on the neck.) Sometimes the negative would be held at the base of the occiput, over the exit of either the occipital nerves, while the positive was a little lower, and the current let on gently and increased very gradually until it produced the peculiar thrill or upward spraying sensation, that radiated over the back of the head to the top, for a few minutes; and then removing the negative to the deltoid of the sick arm, with the positive bathed over all the neck muscles that were affected. This occupied some five minutes.

Next, the positive was glided to the back of the shoulder joint, and the negative to the lower part of the pectoralis major, where the current was increased double, or all he could well bear, and thus continued for five minutes more. Then the negative was planted stationary on the *back* of the swelled and trembling hand, and with the positive at the occiput, I let on all the current he could bear, which, however, was not much, and so began to bathe the neck, the cervical spine, the posterior and anterior regions of the shoulder, and so on over the deltoid, and down the fore-arm to the wrist, where it was retained, with a benumbing impression, for a few minutes — some fifteen or twenty minutes in all. But as he could bear a little more at each seance, the time was to be shorter. Oiled silk, as a sleeve of it, to be worn on arm, shoulder, and neck. No friction or liniments, no medication of any sort, excepting a hop pillow which he had long used, until I could see the result of the electric treatment.

Next day he came with the report that he was relieved for a time, but, on the whole, had more pain than usual. Repeated the faradaic current as before, and then finished the seance, or the last few minutes of it, by substituting the *wire brush* as the positive, the negative sponge still being on the hand, and so faradaized the neck, occiput, cervical region, the trapezius and pectoralis and deltoid muscles especially, as also the whole arm somewhat, by the painting or *brushing method*, but which

hurt him not a little. The skin was reddened by it, except over the indurations, which remained pale and glossy.

The third day he came with a marvellous story of relief and rest. He was not free from suffering, pain, and discomfort for a moment, but said the distress was much less. No new head symptoms, less shaking of the head, and less trembling. Repeated the last proceeding in full. In short, this was followed for a week, when he was decidedly better. He felt so, and his friends said he was stiller and slept more.

Second week, applied galvano-puncture with only two cups, and two needles three inches long, inserting one in the upper and back part of the deltoid, on the back edge of the induration, while the other was inserted over the insertion of the deltoid, carrying it downward and inward the full length, just so as to glide in front of the bone. (The needle should never be allowed to prick the periosteum, for it can thus set up a new rheumatic, painful spot.) The seance was finished by faradaizing the neck, spine, shoulder, and arm. This, next time, was done by inserting the needles at the upper spine, and thus it was alternated with the previous applications every other day. Prescribed for him *formulæ* 2, 10, and 38, to be alternated every five days with 1, 19, and 24; oiled silk to be worn on the neck, shoulder, and arm, over the saturated cloth.

At the end of the month he was so decidedly improved that he took fresh courage, and thought that after all he might yet get well. He could already lie down and rest some nights; his arm could not only be moved, but he could move it voluntarily, carrying it two feet or more from his side, and also bringing his hand up to his mouth; but he could not carry it much back behind him.

The improvement was so great that I reduced his sittings for the next month to three a week, or only about a dozen a month; to which were added some gentle handling and deep-shampooing. At the end of the third month the roaring ceased in his ear, and he had some hearing in it. The head-rest was dispensed with, and he could ride without the jar producing distress. The indurations on the arm were the slowest to recover from. A mass,

for a time, seemed to increase about the insertion of the pectoralis into the humerus, and this was the last to yield. The degenerated neck-muscles were more rapidly restored than the atrophied trapezius, deltoid, or pectoralis. But he has now entirely recovered from all pains, and stiffness, and suffering. The shoulder joint seems some hampered, so that he cannot freely get his hand behind him to button a suspender; but there is no pain; and his brain is becoming as vigorous as formerly. I have thus delineated minutely all that was interesting in this case, because it fully illustrates the character of the disease, and the treatment that can cure it.

Rheumatic effusion also forms *periosteal induration;* but this is usually attended with other effusions in the tissues. These are designated as *rheumatic nodes.* There is one very prominent symptom, viz., *burning pain*, which is always severe and lancinating through the limb, radiating from the nodes. Pressure upon these spots is not generally painful, but the application of the faradaic current is most intensely felt, and may be employed for pointing out their situation. In some cases there is an occasional sensation at the site of the node, as if the bone were broken, or paralyzed. These periosteal indurations by rheumatism are among the most violent and obstinate of rheumatic complaints; often assuming the form of intense *neuralgia*, or of some deep-seated disease of the bone, and require very energetic and persevering treatment to produce absorption.

*Treatment.* — *Electricity, and oiled silk* or thin rubber for covering the part, are the remedies *par excellence* to this end. The current should be applied every day, and the oiled silk or tissue rubber should be worn full half of the time, for promoting the absorption of the rheumatic deposit in all these forms of pain and palsy from rheumatism. Where there is produced too great pain, apply and glide the sponge electrodes all *about* the affected part, and so make all the region to feel its influence; and then mellow and shampoo deeply, and cover for a few hours with the sweating silk or rubber tissue. In the older cases, where there is degeneration of muscle tissue, acu-puncture or galvano-puncture can aid beyond all other remedies. But if employed earlier in these cases, pain would be increased.

There is a kind of *chronic rheumatism* which we not unfrequently meet with, that shows its peculiar character by deposits in the cutis, in the sub-cutaneous cellular tissue, and also in the cellular tissue of the muscles. These considerable effusions very speedily become hard callosities, and are not only felt but *seen*, situated in isolated spots, or else are numerous in a given space, or conglomerated so as to cover a larger extent, and so near the skin, or actually involving the under structure of it, that a fold of the skin cannot be pinched up over such spots. These are attended with harassing pains, and even loss of power, to helplessness; while other cases suffer little from them. But if early treated by localized electric currents, these lumps can be solved away, without being scattered to any other part. A brisk current, directed through the spots, is required, and that continued for a longer time at once on each callous spot, than we are in the habit of using the current for any other purpose.

Rheumatism does *not* appertain to cell life, as its characteristics of pain, shifting of seat of swelling and of the pain, formation of lithates and its deposits, do certainly indicate. Rheumatisms which are more frequently presented for electrical treatment are of the *chronic forms*. In all reason and fairness, too much is expected of electro-therapeutics in most affections for which they are resorted to; and particularly is this true in those cases where there is a rheumatic *taint*, discrasia, or diathesis, for this special condition or bias of the organism is always giving occasion for fresh attacks. Notwithstanding, we are prepared to show the preëminent power of electricity in pure forms of rheumatism of every sort, excepting only the actively acute.

Chronic rheumatism of almost every sort, whether capsular and seated in the lining membrane of the joints and bursæ of the tendons, or when it attacks the feet or the hands, the hips or shoulders, the knees or elbows, the muscles, fascia, or periosteum of the skull, vertebræ, or shafts of bones, — all, all of them are wonderfully amenable to the catalytical power of Galvanism, or the disturbing force of Faradaism. It is known that the pain of these chronic forms is sometimes confined to one or several joints; and at another time, it shifts from one part to

another, and that without being attended with inflammation or fever. The patient is very liable to become lame, or even crippled by contractions and pseudo-anchylosis, and liable moreover to frequent painful recurrences. The effusion of coagulable lymph, after each fresh attack, tends to a permanent thickening of the parts. Now, unless these deposits have existed very long, or have far degenerated into old cartilaginous, callous, or chalk and tendon nodosities, so as to greatly resist the in-working of the current, electricity, and particularly that form of it we designate as primary or galvanic, and even electro-magnetic currents often, can solve out and remove these deposits of effusion, wherever their seat may be, *if recent.*

Rheumatalgia, then, even where it resists all other treatments, can often be reached and nearly eradicated by the correct and thorough use of electric currents, at least for that time, so as no other remedial power can do it. If a rheumatism is thus treated and broken up at every new attack, for a few times, if the urine testifies that the kidneys are at fault, and they can be corrected, if the diet and habits are corrected, the assimilation and disassimilation are rendered efficient in their respective offices, and the patient wears flannel and woollen clothing, *the rheumatism is cured.*

The more speedy and *effectual* throwing off a fresh attack of rheumatism, whether in the bones or muscles, is very greatly facilitated by baths of soft warm water and a plenty of soap. The water should be quite *blood warm*, but never over 95° Fahrenheit. The air of the bathing room should invariably be within 10° of the water of the bath, and the patient should exist day and night in a very uniform temperature.

*Ice.*— For some chronic *hot* rheumatic joints, which are swelled with a morbid inflammatory state, and we find we cannot use electricity, *because all hot applications increase the pain and stiffness*, (and by this we know the proper cases,) *congelation* comes, like another Samson remedy, to our aid. From experience I know it is capable (but only when the cases are well chosen) of immediately and permanently relieving the pain and subduing this peculiar inflammation or congestion of the

part to which it is adapted, if rightly applied. Its action is mainly local, but also somewhat revulsive. The method is this: Take a bit of ice, that would weigh from a half pound to a pound, and place it in strong cloth or canvas, and crush it with foot, flat-iron, or hammer, to the size of rock salt; then throw it into a large bowl or basin, and mix with it about half of its weight of common coarse salt, and quickly pour the whole into a thin india-rubber bag, oiled silk, or cotton cloth; apply at once over the tenderest part on one side or both sides of the affected joint, and retain it there for five or six minutes. It is attended with a smart pain at first, then there is a dull ache, and then a numbness. But when the ice is removed, to prevent too sudden reaction, it must be replaced by a single thickness of wet cloth for evaporation, which is to be retained wet for an hour or two longer. Next day, if there are redness, tenderness, and pain, it should be repeated, until no pain or stiffness remains. A constitutional treatment can aid in establishing the cure.

*Rheumatic Bronchitis.* — This is not so rare an affection, as we frequently see cases which we can term nothing else. There appear to be different degrees of this affection, i. e., being more rheumatic, or more a simple bronchial irritation. The majority of cases of rheumatic bronchitis that we see, exist in the chronic form, although more acute cases occur than physicians recognize as such. The irregularity of its course, the seeming caprice which rules its exacerbations and its subsidences, and its amenability to those remedies which are found useful in relieving the arthritic rheumatism, will aid us in judging between bronchitis and rheumatic bronchitis. It is often aggravated by the warmth of the bed, or by the horizontal posture, like arthritic rheumatism in the shoulder; the dyspnœa, or cough, becoming almost suffocating, and being speedily relieved by a copious expectoration. Peppermint, or hive sirup, is excellent for this; but *sweet oil*, in tea-spoonful doses, often taken, is the most curative.

The treatment which has been found most successful consists of electrifying the throat, and giving a combination of sweet oil with the alkalies and opium for the acute form; with the addition of iodide of soda or potassium in sirup of senega for the

chronic form; with dress and care as to exposure to cold, damp, and changeable weather, as in any other treatment for rheumatism.

*Pleurodynia* may be a limited form of pleurisy, which speedily contracts adhesions; but this name is more properly applied to a muscular rheumatism affecting the intercostal and other respiratory muscles. The diagnosis rests on the absence of febrile disturbance, the existence of superficial tenderness, and in the pain not being a sharp stitch, like that of pleurisy, but rather a diffused soreness, as if the side had been bruised; as also the fact of its being excited by any muscular movement of the chest, as bending or turning the body, or lifting the arms. It occurs as a sudden attack of pain, which impedes the breathing, and catches the patient in attempting to cough or inspire deeply. The faradaic current applied as *hazing*, or in double-circle movements, through large sponge electrodes, is the sovereign remedy. Hot applications for the night, with a dover's powder, or a mustard plaster, will aid in eradicating it. Or apply electricity repeatedly, and *formula* 36 between whiles.

*Scrofula Rheumatism.* — By this term I do not mean the ordinary enlarged joints by rheumatism; nor the stiffened tendons, nor the chalky deposits of gout; nor that chronic thickening into bead-like folds about the socket of a joint of the capsular ligament, by a slow old rheumatic affection that mainly hampers movement. But by this term I wish to designate, distinctly, those cases of *chronic* rheumatism the characteristics of which, when fully developed, are *tenderness, pain, heat, weakness, and crippling deformity*. (Fig. 127 is given in illustration.) They are very sensitive to the cold, are mostly delicate, cachectic, and scrofulous or tuberculous. By what other term can I so well define this certainly well-marked and familiar class of rheumatic affections? In most

of them the skin appears of a dingy hue, and feels peculiarly soft and silky, or sick; the flesh is doughy, the muscles and cords are fixed in unequal balance, so as to distort the position of the bones, and a hideous crippling deformity is the consequence.

We find scrofula rheumatism — termed by one *gouty rheumatism*, by another *neuralgic rheumatism*, by another *chronic inflammatory rheumatism*, &c. — most frequently in the more delicate persons, who have developed, or inherited, a scrofula-*tending* constitution, (but how few will admit this!) which only required a cold or a poison, an attack of fever or eruptive disease, rheumatism or neuralgia, or an injury, to awaken this crippling, deforming, scrofula rheumatism. It is usually seen in the hands, knees, elbows, and arms, hips, ankles, and feet; and in about this order of frequency. Electricity, washes, and liniments do no sort of good. A long course of constitutional treatment, as by *formulæ* 7, 8, 9, given once a day, and long continued; aided by daily deep-shampooing, farinaceous diet, and no meat; air and exercise, or riding in the country, can wonderfully relieve such persons if they have patience and perseverance.

*Rheumatalgic.*—The following is a good example of very many cases which I find termed by the patient "*rheumatism.*" In a word, they are characterized by spots or regions of pain and swelling of the periosteum. These patients, the most of them, are enfeebled and cachectic, and many of them, (but not all,) doubtless, have suffered from syphilis. They are evidently cases of sub-periosteal effusions from rheumatism, syphilis, or scrofula about the large bones.

*Case.* — G. C. A. had been under regular medical treatment, and still suffering from pains in his limbs for nearly a year, which nothing relieved. He had a large, firm, but tender node on the left shin bone, and one large one and three or four smaller ones on the head; and effusion into the capsule of the left knee. He had had what he called catarrh, but positively denied having had any degree of syphilitic disease. He believed it, but I did not. His countenance was wan and sallow; but his stomach, bowels, and kidneys were not apparently deranged. The heart's action was regular, and its sounds were clear. I immediately

prescribed *formulæ* 7 and 8, and commenced applying the extra current through the knee joint pretty strongly every day; the nodes receiving three to five minutes' application each, by placing the moist-sponge electrode on either side of a painful and tender spot, with all the power he could bear, so as to have the current pass through it. From the very first applications, he began to improve; said he obtained the first good night's rest in a year. The cure was complete in two months; the pains and nodes were gone; his rest, strength, muscle, and flesh were restored, and he considers himself in the very best of health.

The foregoing is a fair example of this rheumatic (?) disease. Sometimes a case will show effusion into the capsule of the joint, wandering pains in the limbs, inflammation of the eyes, and of the periosteum on the large bones in patches; and if neglected, or wrongly treated, there follows, in the train, disease of the bones; while deafness, headache, and epilepsy result from the pressure of nodes insidiously formed on the internal table of the skull. The patient always appears cachectic, and must be supported by nourishing food; while quinine, iron, and iodide of potassium, and perhaps some biniodide of mercury, are necessary to radically rid the patient of this miserable malady. But so sure as such a case is treated as a rheumatism, relying on baths, alkalies, guaiacum, colchicum, sulphur, and other anti-rheumatic remedies, time is lost; the pains not only continue unrelieved, but there is a gradual progress from bad to worse, until structural disease of the bones is in process, the vital forces are poisoned, perverted, and exhausted, and the mischief is irremediable.

*Gonorrhœal Rheumatism.* — This is very peculiar. Like the so-called rheumatic affection we have just been considering, it is *not* cured by the ordinary remedies that cure rheumatism. The warm baths, hot-air baths, and sulphur baths here fail; the iodide of potassium, colchicum, guaiacum, and sarsaparilla disappoint. The obstinate swelling of the ankles or knees, feet, wrists, or finger joints continues, and the wandering pains in the body and limbs torment the patient just as much as before such treatment, though followed for many months. My own convic-

tion is, that this disease is due to a specific poison, and only *resembling* rheumatism by the pains and swellings of joints, and is never attended with inflammation of the heart. Its origin is fairly connected with a relapsing or persistent gleety discharge from the urethra — the result, as Dr. W. H. Fuller has suggested, not of a venereal taint, nor from that which occasions ordinary gonorrhœa, but from some peculiar form of vaginal poison which may and does rarely occur in an honest woman! But whether this is so I dare not say; yet we know gonorrhœa may sometimes so originate.

One well-marked case, under my care, I am satisfied could be accounted for only by tracing it to his previously healthy wife, who had miscarried but a few days before, and was at the time having some lochial discharge. In spite of copaiba and cubebs, urethral injections, and all the anti-rheumatic remedies, he had still the purulent gleety discharge, (which could be pressed from the urethra in the morning,) as also swelled ankles and sore ribs, for seven months; and which were in full force when he came to be under my charge. The lameness followed the first appearance of the gonorrhœa in about three weeks; the gonorrhœa followed the connection in two days; but he repeated the exposure on the third day, not suspecting any thing.

He had been a remarkably vigorous, healthy, and business-devoted man up to the time of attack. Now he was pale, pulse 100, tongue clean, urine clear, and so lame that he had to use two canes to hobble along from the carriage into the house. The ankles were enlarged, the feet tender, the ribs and back painful. He had but a slight gleety discharge, but in the morning could squeeze out a little thick matter from the urethra, which had made its appearance from time to time since the first month.

*Treatment.* — Electrified the painful parts and the swelled joints for ten minutes daily, through sponge electrodes; to be followed with mellowing and gentle handling for five minutes. In the evening to place the feet in a deep bath of cold water for ten or fifteen minutes, and then, before wiping or drying them, to have them rubbed, mellowed, and deep-shampooed, all he could bear, until supple and warm; then to be wrapped in the lotion

of *formula* 8, covered with oiled silk, or cotton, or silk cloth for the night; to take prescription No. 7, and use an injection for the urethra of acetate plumbi four grains, powdered gum-arabic one drachm, aqua two ounces. In one week the gonorrhœa was stopped, and he began to mend fast, so that in a month's time he returned to his home and business, cured. He has called on me once since, to show how well he was, and to express his thanks "for getting out of those woods," as he termed it. For very many chronic stiffening and thickening of joints, and for periosteal effusion about bones, this mode of treatment works admirably well.

Dr. Fuller, of St. George's Hospital, in his work on Rheumatism, Rheumatic Gout, and Sciatica, page 456, says, if the sciatic nerve is the part implicated in the real rheumatismal pain, he orders the whole affected limb to be encased in flannel that is thickly sprinkled with sulphur. This flannel is kept in place by means of a bandage, and the whole limb thus bandaged is covered with oiled silk, or rubber cloth, which has the effect not only to increase the warmth of the limb and confine the vapor of the sulphur, but it also obviates the disagreeable odor. The bandage and flannel should be kept on day and night.

Here, doubtless, is an old *galvanic* remedy, which Dr. O'Conner has brought up anew as valuable in given cases of rheumatism. To be effective, so that good results may follow the external use of sulphur, the flannel and bandaging should not be removed until after several days — say three or four at least. Where the case is attended with *feverishness* and with very acute pain, experienced even when the limb is at rest, no relief results from its use; nor is there any good from it when the skin is dry and inactive, for, in such cases, the sulphur remains unabsorbed and without curative action. But, he says, where there are no symptoms of active disease, when the pain is of a *dull, aching* character, and is felt chiefly, if not solely, when the limb is in motion, — and more especially when the skin acts freely, and the sulphur is absorbed rapidly, so as to require renewing every third or fourth day, — then nothing is more serviceable than the *sulphur bandage*. In these cold and old cases of rheumatism, the sulphur may be taken internally, with some

tincture of guaiac, or the citrate of ferri and quinine, and, at the same time, actively apply electric currents, according to the rules for the rheumatic cases, and the recovery will be greatly expedited, and the cure (?) will be more likely to be lasting.

*Face Rheumatism.* — There is a kind of *face-ache* which cannot be recorded, properly, as a species of neuralgia; for it does not occur in short, stabbing paroxysms, nor is the pain acute enough to entitle it to the name of *tic douloureux*, but which is, notwithstanding, very common and distressing, and, under ordinary treatment, is often very intractable. This is called, by some, a rheumatic face pain. It occupies the lower part of the face — the jaw especially; but the patient cannot tell you exactly whereabouts it is most intense. It is often thought to proceed from toothache; but perhaps the teeth are all sound, or suspected teeth are extracted with no relief. This pain is doubtless *periosteal* rheumatism, and proceeds from a cold; or it may sometimes be a muscular hyperæsthesia, or even partaking of both of these. If not inflammatory, we are to apply electric currents as for neuralgia, and give the patient iodide of potassium in five-grain doses, which will speedily work a cure. When this does not succeed, which is very seldom, then the muriate of ammonia, in half-drachm doses, well diluted, and given every six hours, will soon eradicate the malady.

Case. — Everett G. presented at my rooms for electric treatment with old rheumatic contractions of the flexor muscles of the right forearm. This was an extremely bad case of general rheumatism, which appeared to affect him in all his extremities, showing swellings or enlargements in both his hands and feet; but the greatest suffering was about the right shoulder joint, and so down the arm.

*Treatment.* — At first, gave him a sitting with a current from twenty Daniell's elements, through and through the shoulder from front, backwards, by placing the *positive* electrode over the upper portion of the pectoral muscles, while the *negative* was over the nerve *circumflexor humeri*, and this was maintained for two minutes. I then moved the negative a little to the posterior lower portion of the muscle *deltoides*, for two minutes more;

next from there to the nerve circumflex for two minutes; next from there to the *fossa supra spinata*, with an *up-running* current; this finished the *seance*. Next day found him greatly benefited, not only in that arm, but every other way; repeated such applications for ten days, when the contractions of the arm were quite gone. The next few days directed the current *upwards* through the extensor muscle *triceps*, and *downwards* through the flexor muscle *biceps*. Progress now very great; can lift his hand to the top of his head, which he has not been able to do before for ten or twelve years. He was encouraged to continue to come once or twice a week, and the after-sittings were devoted, respectively, first to this joint or limb, and then to that, until he was almost as supple and well as ever.

Case. — Joseph M., of Cambridge, nineteen years of age, had uniformly good health; his mother is very rheumatic; was attacked with *wry neck*, one day after skating, some two months ago; head turned to right side and firmly fixed by the apparently double process, viz., paralysis of the left *sterno-cleido-mastoideus* muscle, and the clavicular portion of the *trapezius* on the one side, while there is a firm tonic contraction of the antagonizing muscles on the other; and these were as hard as wood, and utterly disabled him from holding up, rotating, or swinging his head in the least. The contracted muscles are painful to pressure, and are evidently ready to pass into a state of atrophy and degeneration.

*Treatment.* — I first placed a large moist sponge electrode, which was the *positive*, near the base of the skull on the contracted side, with the *negative* electrode slid along, from half minute to half minute, from one to the other, on the lower portions of all the contracted muscles, with a current from twenty Daniell's elements, until their polarity was fairly modified; and then the electrodes were removed to the opposite side and placed *reversed* on the relaxed and palsied muscles, employing a stronger *up-running*, *prevailing* current, but taking care to produce strong and rapidly succeeding contractions in those muscles, both by suddenly breaking the current, and by reversing the current by the *current-changer*. In five sittings this patient was perfectly cured.

Case. — M., a young lady, twenty-four years of age, presented

for electric treatments; had suffered from long stages of ill health, and even from infancy had had throat affections again and again, as sore throat, inflamed and ulcerated tonsils, enlargement of tonsils, inflammation of salivary glands, catarrh, and, at the same time, there were painful swellings of some of the flexor muscles of the arms, which had been repeatedly treated by Faradaic currents. I undertook the case, and first applied the primary current of galvanism daily for one month, mainly by embracing between the electrodes the enlarged and hardened glands about the throat. The effect was truly surprising, for after a few days, some large masses about the neck would actually shrink and disappear while under the current and strong pressure of the electrodes, at a single *seance.* In the subsequent sittings the current was often run from the brachial plexus to the tender and contracted muscles of the arm and forearm, and then *up the extensors* of the hands and arms, which were wasted and greatly enfeebled. In eight weeks from the commencement of these treatments the hitherto helpless, distorted, and painful fingers and hands could be opened and shut, and the arms could be well extended, but not much rotated; however, she was enabled to undertake light hand work. It is now ten months since she was dismissed, and her still further improvement in general health, in the appearance of her neck and throat, and in the use of her hands, is quite as astonishing as her early and speedy improvement while under this treatment, after having resisted all other means for a lifetime.

Case of Mr. William Wood, repairer of wet cellars, builder of drains, was often and long exposed to wet; has been subject to rheumatism whenever he is in the water and mud for any length of time; was formerly inclined to perspire very freely upon exercise, but now whole body and limbs are dry and show "*goose-flesh;*" is very chilly upon first removing his clothing; both feet swell greatly, with more or less swelling as far up as to the knee; this swelling goes and comes pretty regularly every three or four days, with more or less pain and stiffness, twitchings in the muscles of the lower limbs at night, particularly soon after lying down to sleep; occasionally extremely severe

pains in hips, one or both, but no pain there just now. On the whole, is weaker on the right side than on the left, in the arm as well as leg; protrudes the tongue with great trembling; tongue deeply indented on its edges with the teeth; eyes twitch, and there is a general stiffness and insecurity of movement of the whole body, which has increased greatly in the last few months; momentary twitchings of the muscles in the different parts of the body and limbs: the evidence of peculiar debility was every where very marked.

With this view of the case he was treated by primary currents, using at first from twenty to thirty Daniell's elements, and placing the positive electrode over the second lumbar space while the negative was pressed, for one minute, deeply into the glutei over the great ischiatic nerve trunk; then, removing the positive to a place over the femoral nerve trunk, under Poupert's ligament, while the negative was removed to the inner ankle, and the current let on as before. The *cauda equina* appeared to be the very seat of the difficulty, notwithstanding a dull pain in the head and a somewhat hemiplegic appearance of the disease; therefore the negative pole was mainly planted there for *circle* treatments, also when directing the current down either limb. He was advised to keep dry and warm, and this method of application of electricity to be kept up regularly every day. In three weeks' time he appeared, and said he felt, like a new man; the trembling of muscles entirely gone, the pains were scarce and far between; he was able to walk and move about with considerable freedom and ease to himself — to continue the electric *seance* every day for ten days more. This man completely recovered, and is now well for doing business, and possesses remarkable powers of endurance.

The *cauda equina*, it must be noted also, is a most frequent seat of protracted neuralgia, without necessarily involving either the spinal cord or its theca in any change of structure. The evidences of such neuralgia are aching or burning pains in the loins; stooping gait; tremblings in the muscles of the loins and thighs, particularly after fatigue, when there is also experienced great weakness there, but not actual paralysis. Now, in all these cases, the *circle treatment* will best wash away *the*

*pain-causing condition*, whether we employ the galvanic or the electro-magnetic currents.

*Dolor spinalis*, or that pain which occurs in the back, particularly in the spinous processes of the vertebræ, and which is so characteristically *augmented by pressure*, and therefore put down always as "*spinal disease*," is not, by any means, always truly so; for I find, among these cases, a large majority of instances of simple and true rheumatic periostites, in varying stages and degrees, from the dull ache and lameness of chronic rheumatism, to the very acuteness and twingings of neuralgia, and sometimes even equalling the burning and throbbing sensation which characterizes inflammation of the periosteal coverings of the spines and bodies of the vertebræ, only it comes on in very distinct rheumatic-like attacks, whereas in inflammation it is more persistent. *Circle treatments*, with Faradaic currents, will cure this; and then the internal administration of the iodide of potassium, together with restricted labor and habits, can fortify the system against the culminating of this pain-inducing condition.

*Rule.* — In those cases where there are "*contracted muscles*," and if these, for example, are mostly about the shoulder, then we are to apply one electrode on the arm below, with a one-way *down-running* current of primary and constant galvanism; since, from all past experience, this proves the best means for permanently relaxing them; but in those cases where the muscle contractions are farther down on the arm, or in the hand, then the *up-running* current will the better succeed, provided the direction of the current in either case is never reversed on the same muscles for flexion, at the same *seance*. Yet a constant *down-running* current, led, for example, from the pectoralis to the palm of the hand for one minute, may be succeeded by an *up-running electro-magnetic* current *on the extensors* of that same limb for *half* a minute, and thus alternated for two or three or half a dozen times with extra good effect; indeed, thus succeeding where either may have failed before.

When muscle rheumatism has its seat either in the muscle fibres or in the fascia just under the skin nerves, it may be

known by the flying pains, and the extreme change from place to place; and this characteristic is still more marked while the electrodes are being applied. Here then the quick touches and lively-gliding movements of large and soft electrodes and smart currents are very often sufficient to chase away at once all these pains. The best way is to attack these pains boldly, holding and *moving* the electrodes all the while with but a few inches between them, allowing no painful or tender spot to go untouched, until all pain is eradicated, and so that the contracting of the muscles or any motion of the body or limb cannot reproduce it. I find that *labile contractions* of the muscle fibres are really required to exterminate *this condition* for pain, as also to loosen the stiffness of the joints below where the tendons of the muscles are inserted. Such persons must be advised to *avoid a damp air*, either as a place of business, or lodging or residence, and to wear their flannels in summer, and thick flannel in winter, until a painless *habit* and *endurance* of the nervous system of that person become established.

*Painful-Palsy, located in the Shoulder and Arm, Hip and Leg.* — Among the numerous cases of painful shoulders and arms, hips and legs, sprained, rheumatic, and neuralgic, that apply for electric treatment, there is now and then an old case, — a class of them, — that I must designate as the *inveterate lameness*, or a local painful partial-palsy; for most intractable cases the greater part of them are. But what ails them? Who has described these unique cases, or the treatment that will cure them? They are not exceptional cases, for many do occur; are not ordinary palsy, for they are but partial, and are painful. They are not inflammatory, nor fairly or simply rheumatic; for all anti-phlogistic and anti-rheumatic remedies fail to help them. It is not simply neuralgic, for it resists all neuralgic remedies. Nor is it a self-limited disease, for it continues for months and years; generally with a tendency to become worse gradually; the pain rather diminishing, but the palsy increasing; and if at any time pressed into service, the pain and lameness are very much worse; if actively treated by friction, movements, liniments, and other means useful for ordinary lameness, it will

hasten all the faster into fat and wasting, or fatty degeneration and palsy. Neither the arm nor the shoulder, the leg nor the hip, is ever very much swollen ; usually none. But the hand cannot be readily brought to the head, nor carried out horizontally, nor carried back far ; if in the hip, the leg cannot be abducted, and in fact any considerable motion is distressingly painful. In either case, lying down in almost any posture, increases the pain. There may be pain below the elbow or the knee, but the seat of the affection is evidently above.

These patients, for the most part, can give no account of the cause of their most serious lameness, only that it came on insidiously, and holds on. Some, however, say they recollect of having hurt the upper arm, or the shoulder ; one by a strain, another by a fall, or a blow ; another had been exposed to a draught from a window in church or in a car ; others had often and for a long time together *tired* the arm by monotonous work, as writing or sewing. One bad case said he had received a blow on the arm just below the shoulder, evidently on the deltoid ; another incurable case, sent me by Dr. Jones, the city physician, ascribed it to violent pushing and lifting ; another to leaning for a time against a cold marble column. But the most know of no reason sufficient to account for so much and so protracted lameness and suffering. No doubt exists in my mind, that this constitutes some of those intractable, *inveterate cases of sciatica* that we now and then meet with, and fail to cure as a supposed neuralgic, rheumatic, or sympathetic sciatica ; excepting, of course, that still more rare class of cases of *incurable* rheumatic "*permanent thickening*" of the capsular ligament of the hip joint ; and which occurs rarely about other joints, and which also impedes free movement. But these latter cases are known by being painless while still, and while lying in bed, if moderately used ; but are painful in proportion to the labor or straining work.

Finally, these cases of *inveterate lameness*, or painful-palsy, which seems so far more frequently to involve the arm and shoulder, than elsewhere, are due to a peculiar rheumatic deposit or nerve injury — more probably both — in the axillary or

cervical plexus of nerves. It is either the result of an attack of rheumatism, or is produced by the local action of cold; or by strain, pressure, or blow; or by undue fatigue from monotonous taxation of the part, in a person whose general nervous energy is already reduced below par; that is, enfeebled. There being more pain than palsy, and the patient usually seeking relief from the former more than the latter, lead me to treat of *painful-palsy* here, rather than in the chapter of palsies. A peculiar treatment is required for this peculiar lameness, the result of rheumatic induration involving important nerves; therefore two or three cases will here be given to illustrate a proceeding that usually is crowned with success.

The first case I will here give was not hurt in the arm or shoulder; in this instance, it being the result, doubtless, of a slight bruise on the chest, over the anterior thoracic nerve, starting a morbid action which was propagated up this nerve to the bronchial plexus, and radiated to some of the joint nerves, to shoulder and arm nerves, and causing fatty degeneration of the lower portion of the deltoid muscle, which was attended with pains and extreme weakness of the whole right arm.

Mr. K. was a member of one of the oldest firms and heaviest dry goods houses in Boston. Very early one morning, some years ago, while leaving the cars, on arriving in New York, he was struck in the right breast or side by the tongue-pole of a hack, that was driven carelessly upon him. It hurt him at the time but little, and he soon entirely forgot it. Some time after, however, he found that his right side and breast felt sore, and some tender to the touch. This gradually increased, so that in a few weeks there was also pain during attempts at full inspiration. Applications were made, and this was very much relieved; but soon after, the arm and shoulder grew lame and helpless, more and more as the side and breast became better. He had the services of the best medical skill, without avail. At this juncture he came for electric treatment, having consulted one of our best surgeons, Dr. H. J. Bigelow, who immediately advised him to try it.

He complained now mostly of *pain* on the outside of the arm, of a stinging, pricking nature, mostly situated deep down

on the upper third of the arm, (pointing directly at the lower portion and insertion of the deltoid;) suffering also with a dull, deep aching in the shoulder-blade and joint, but at times he could not describe where; with occasional flashes or dartings down the ulnar nerve to the wrist and little finger, and nearly all the time with a heavy pain just on the top of the shoulder, in the anterior portion of the trapezius. There were times when the pains were mostly in the supra-clavicular space, or in the infra-scapular region, or more in the posterior portion of the deltoid; thus embracing the region of the circumflex nerve, the musculo-cutaneous, and the nerve of Wrisberg. Nights were the times for the most disquiet and pains. He could not sign his name; nor could he lie in bed without great suffering. It was with the greatest difficulty that his loose coat could be put on or off. Opiates, water dressings, leeches and blisters had all been fairly tried. Repeated sub-cutaneous injections of morphiâ, together with a great variety of anti-rheumatic and neuralgic remedies, had utterly failed to give any more than temporary relief; while of late the upper arm muscles wasted faster, diminished in natural heat, became soft, flaccid, and hyperæsthetic, and were weak next to absolute palsy.

Coincidently with the increased pain in the arm, the triceps and the coraco-brachialis, the pectoralis, and the trapezius — all the shoulder, chest, and arm muscles of that side — were reduced in solidity, warmth, and size, and the sight too was seriously affected. Below the elbow was least softening or wasting; but what was equally remarkable, and is usually so in these cases, there was a rheumatic deposit or thickening in the fascia over or about the insertion of the deltoid muscle on the humerus; and this is the point I invariably attack in the treatment for the cure of these cases.

*Treatment.* — Prescribed *rest*, not only for the arm, but also for stomach, body, and mind; quiet, *without* friction of lame parts, not even rubbing with a towel; free bowels, plain nourishing diet, *no stimulants;* bromide of potassium at night with half grain of opium, (see *formulæ* 1, 9, and 7, in appendix,) simultaneously given for some time. These being premised, I made electro-puncture in the lower portion of the deltoid, with

two three-inch gold needles insulated, inserted in its back portion downwards and forwards, and applied the primary current of two elements for ten minutes; to be repeated every other day for three weeks; the arm to be supported in easy postures. At each seance, the needle insertion caused but little sensation, which became less and less, as also the pain, and there was sensibly less fat to go through, and less rheumatic deposit felt near the bone between the points of the needles. A large and soft belladonna plaster was worn on this portion of the arm between the sittings, for two days at a time, alternated for the next two days with an unction of mercurial ointment fortis, by the warm hand and before the fire at bed-time, to be covered with oiled silk or cotton-flannel. In two months this was a complete cure. He has now been well for four or five years; has since worked hard and written nights; made a fortune and retired. And still he is well.

*Sciatica*, the most marked examples of it occasionally occur as just such cases. They puzzle, for they appear to be either or neither inflammatory, rheumatic, or neuralgic, strictly speaking; but as some mal-condition of the nerve and muscle both, which they are, and which proves exceedingly obstinate. I am sure I am enunciating the opinion of the profession when I say that these shoulder and hip cases are amongst the most obstinate and heretofore inscrutable kinds of lameness we have to deal with. The most certain of all methods of treatment, medical or surgical, that I have found, is the electro-puncture, or localized faradaization. If the former is objected to, employ the latter; but premise the prescriptions and regimen as in previous case. Then let the patient lie on the well side, and being provided with a very smart current, apply through the wire-brush or metallic electrode for five minutes, mostly over and about the exit of the sciatic nerve, while the other pole, positive, is planted at the lumbar spine; then extend the sweeping of the brush, or button electrode, over the sacrum and all the glutei, and so on down over the thigh and leg for five or ten minutes more, with full battery and helix power; repeat this every day or every other day. But if this were connected with or alternated with

electro-puncture, as described in the previous case, the cure will be expedited, and more sure and lasting.

There occurs an *exceptional* case of sciatica, as well as of back and shoulder, which we must look out for, that evidently is an old *rheumatic chronic thickening into folds of the capsular ligament about the joint*, that prevents the natural extent or latitude of motion. Here the main difficulty is, the motions of the joint are hampered, so that it is difficult to put on the shoe or boot, and *much* exercise renders it painful. Otherwise it is not painful. It will probably make the person lame for life, and yet not in the least shorten life. I know of no means for curing these exceptional cases, which are so well marked.

Another of these cases was Esqr. H., who had some years before an attack of acute rheumatism, with which he was laid up for some time, but of which he quite recovered years ago. Was taken last year with an increasing pain and lameness in the right arm, for which he consulted our best medical men, and finally came to me, by the advice of Dr. E. H. Clark, for what was supposed to be simply a neuralgia of the fore-arm and wrist, with a pain darting down to the little and next finger. He knew of no cause for this tormenting and alarmingly increasing pain and lameness. I applied electricity, but it did only temporary good; I did not discover then the true nature of the case. He bought a horse, left business, and rode for months among the White Mountains; came home no better. He went to Europe, and spent a good part of a year there with his lady, at leisure, visiting spas, consulting the best men; and was for some time under the care of Dr. Duchenne, of Paris, for localized faradaization. It relieved him temporarily, but he was no sooner home than the *inveterate pains* and *lameness* came also.

He came to me again, with all this story. I now stripped his shoulders, and lo! there was marked wasting of the whole right shoulder and arm to the elbow; softness and almost soreness of all the muscles thereabout. Now treatment was commenced in earnest, with this view of the case; and between the electro-puncture, faradaization, blisters to the cervical spine, and the prescriptions as advised in the foregoing *inveterate* shoulder

case, he is recovered. He now sleeps nights. He writes for hours together. His arm is strong and growing.

*Syphilitic Nervous Affections.* — It has been maintained that in no case does syphilis act on the nervous structure, otherwise than by pressure, produced by conglomerate growths in surrounding cellular or fibrous tissues; but that this is actually a frequent cause of distressing nervous affections, there can be no question. The intense pain often produced by cranial or tibial nodes doubtless results from this fact. Exostosis, when developed externally, is harmless; but if developed from the internal surface of the skull, or spine, it may be fatal; if impinging the caliber of bony foramen for the transit of nerve-trunk, there will be pain, or palsy, or both. And I should say here, one characteristic by which we may suspect or know the pains produced by secondary syphilis, is, that *they occur more usually in the night;* so that, in cases suspected of this origin, this character of pain should be inquired for, and if it proves to be confirmed by other reasons, the case is to be treated specifically, by the bichloride of mercury, or the biniodide, or iodide of potassium, or both alternately, and quickening the treatment by applications of electricity.

There are cases, however, that now and then occur, which go to show that syphilis, in its secondary effects, may act directly upon the nervous tissue, as well as by the development of abnormal growths in the surrounding osseous and fibrous tissues. Dr. Ricord has given several such cases, of which the following, which presented symptoms finally of a general paralysis, will illustrate.

L., an iron-worker, aged twenty-four, was admitted under M. Ricord in March, 1863, with indurated chancre. Iodide of mercury was given for a month, when the patient left the hospital; but in July following he returned, showing secondary eruption, enlarged cervical glands, hair falling off, intense nocturnal headaches, and periorbital pains, with some loss of vision in right eye. Induration of the chancre still remained, and the enlarged glands in groin did not suppurate. Mercurials and iron were given for a month or more, but he left the hospital again not cured.

In the latter part of August he returned once more, but greatly altered. He now appeared in a remarkable condition of imbecility; with difficulty of speech, loss of memory and of muscular power, and was actually confused a good part of the time. The right arm was motionless, and hung down; he looked like a man with partial paralysis; stood stooping as in partial paraplegia, and tottered as if intoxicated.

"September 1. He is losing; is weaker, drowsy, timid, and senses dull; all the movements are slow, but no part perfectly paralyzed. Well-marked contractions of left arm for three or four days came on, and then left it powerless. This was soon followed by the same phenomena in the right arm. Still, he can make out to get up, and stand alone. By the middle of the month his state was precisely that of a general paralytic — fixed eyes, speech slow, stammering, fear of every one, alternate laughter and crying, constipation, loss of flesh, but still good appetite. On the whole he continued to grow worse, and the pharynx became paralyzed; at last coma and convulsions came on, and he died on the 2d of November.

"*Post Mortem.* — Abdominal and thoracic organs healthy. The brain in perfect contact with the dura mater, and without adhesions, but no cerebro-spinal fluid. Pia mater of the convex surface of brain injected, but no exudation; convolutions flattened. *But there was a general softening of all the central portions of the brain*, especially of the fornix, corpus callosum, and interior of medulla. The gray peripheric portion of the brain is spotted, softened, and detached. No tumor, no other disease of brain." Dr. Ricord had one half of this brain analyzed for mercury, thinking the symptoms might possibly be the result of the remedy as much as from the disease; but no traces of mercury were found.

The syphilitic virus, once in the system, *where the chancre is not destroyed within the first five or eight days of its appearance*, can arouse or predispose to various other diseases, or augment their intensity. In almost any such case it may involve the *nervous* system so as to be the cause of hyperæsthesia or anæsthesia, pains, or palsies. It may be the germ and source of pure scrofula, or shades of it, in rheumatism, throat affections, neu-

ralgia, gummy tumors, exostosis, periostitis, necrosis, deep-seated *pains*, deafness, blindness, paralysis, epilepsy, apoplexy. The spinal cord and the brain may not escape; the glands, the heart, the lungs, or the bones, may become the seat of its damaging ravages. In *post mortem* examinations we find abundant evidence of ultimate syphilitic disease of the skull, face, and brain, vertebræ and spinal cord, of the blood-vessels and of the nerves.

*Symptomatology.*—Syphilitic brain disease, the *sequel* of syphilis, presents itself under two forms. The *first:* centripetal paralysis, being a gradual advance of evidently *referred* peripheric nervous symptoms. In addition, we have vertigo, intolerance of disturbance or noise, and impairment of memory, as evidence of this seat of the disease. The paralysis will soon extend to the muscles of the bladder and rectum, producing involuntary evacuations. Paralysis of the external rectus of the eye is an *early*, and sometimes an only symptom for a long time; producing strabismus and double vision. *a.* Change of voice, more or less rapid and complete, is a very frequent symptom. *b.* There may be weakness of the throat muscles, producing a thick and stammering articulation. *c.* Disinclination to give answers; which *are short* as possible, and resemble those of a drunken man. *d.* The strange substitution of words, or of whole sentences, for what the patient intends to say. *e.* Loss of muscular consciousness, or "palsy of the feeling of muscular activity."

Now we know, since Professor Schrœder has shown, that throughout the human body, the sensitive nerve-branches of a mixed nerve-trunk run to that very part of the skin, which covers the muscles that are moved by motor filaments from the same nerve-trunk; or, in other words, that, *as a rule*, a spinal nerve gives its motor branches to the muscles as instruments of motion, and its sensitive branches to the part moved. Therefore, paralysis of these sensitive nerves, the motor branches remaining intact, would evidently seem to produce the lesion in question. But, in these cases, there is not complete anæsthesia; yet always a diminution.

The *second* form of syphilitic brain disease may be termed apoplectic; and is also that which constitutes the termination

of the first, just described variety. This is of much more frequent occurrence, and is much more destructive of the patient's psychical and bodily welfare; and may be manifested within a few months, or not for many years after the taint of the poison. In some, the limbs of the right side are affected; and in others, though less frequently, those of the left; in more rare cases the right arm and left leg; in some the left side of the face and the right arm and leg; in one case the right side of the face and right extremities, with almost total loss of speech, protrusion of eyeballs, and the substitution of wrong words spoken or written; in some, only one limb; as an arm, or a leg. In many cases there was paraplegia; but one leg was always worse than the other.

Is syphilis always the cause of this train of symptoms? I cannot say it is *invariably* so; but we must recollect that Dr. Ricord teaches that syphilis may remain perfectly dormant in the system for *forty years*, and then break out in all its power!

*Syphilitic neurosis* embraces quite a range of manifestations, including also those of the hypoglossal nerves; spinal nerves of the neck; of the upper extremities and trunk; *neuralgic affections of the genitals*, and the syphilitic affections of the sciatic and splanchnic nerves.

Aided by the extensive researches of MM. Léon Gros and Lancereux, we are enabled to make the following condensed deductions:—

1. Direct *syphilitic nervous affections* may exist, without visible organic lesion; but it doubtless depends upon some actual unseen lesion of the nervous system.

2. Indirect syphilitic nervous affections are symptomatic of syphilitic lesions, situated in the organs or tissues adjoining the nerves.

3. Syphilitic nervous affections may be developed at any time, during taint of constitutional syphilis, in the secondary, tertiary, or quaternary periods.

4. Various syphilitic alterations of the nerve-centres, or nerve-cords, present us, then, very varied symptoms, which have been called different affections; and these may fall mainly upon all

or either of the four great functions of sensation, motion, nutrition, or intelligence.

5. Syphilitic nervous affections, which may be without appreciable material lesion, are divisible into, —

6. Neurosis of sensation; as neuralgia, headache, rheumatalgia, formicans, anæsthesia, perversion or palsy of the organs of sense.

7. Neurosis of movement; general convulsions that often simulate epilepsy or eclampsia, or *partial convulsions* simulating hemi-chorea; or there may be *partial paraplegia, showing the staggering gait, with general or partial progressive palsy.*

8. Neurosis of the intellect, as hypomania, monomania, *syphilophobia.*

9. Neurosis of the ganglionic (nutrient nerves) centres and fibrils, showing many cases of *tabes dorsalis* — local or general atrophy with palsy.

10. The insomnia, so frequently observed in children affected with *hereditary* syphilis, is supposed to depend upon the nocturnal osteocopic or rheumatalgic pains.

*Syphilitic Neuralgia*, occurring in the course of the secondary period, is most frequently manifested as tic douloureux, gastralgia, sciatica, or as a neuralgia of the genital organs. But when these pains only appear at a later period, in the tertiary, they may be ascribed to an organic syphilitic lesion, or cicatrix.

*Rheumatalgia Syphilitica* often marks the commencement of a constitutional action of syphilis; and it may occur in any or all the regions of the body or limbs, but most especially in and about the head, near the joints, and in the larger muscular masses.

*Convulsions*, which simulate epilepsy, recur in fits preceded by vertigo, and accompanied with loss of consciousness. But they are known from true epilepsy, *first*, in that the attacks are preceded by headache, and by the first appearance of the attack in adult age; and by the fact of the prompt and permanent cure brought about by well-directed *specific* treatment.

The accessory causes which appear to favor the localization of syphilis in the *nervous system* are, free living, tobacco, liquors,

and excesses of all kinds; a nervous temperament, and also moral causes. The material alteration may be a mere disturbance of the circulation, as congestion or anemia; or it may be inflammation, or softening; — meningitis, encephalitis, ramollissement, retinitis; or by formations in the substance of these tissues, as plastic deposits disseminated or agglomerated in the nervous substance; appearing slowly, even five to fifteen years after the primary attack. Thus being manifested by symptoms almost identical with those of the most of nervous affections, yet, *by observing one, two, or several of these characteristics*, the diagnosis is almost always possible, if not absolutely positive.

*Treatment.* — The preparations of mercury, or iodine, or both combined, or alternated, should be employed, according to the period of the disease, the previous treatment, the severity of the affection, and the state of the patient. In fine, it should be the same as that of any other manifestation of this terrible human poison. If no grave lesion, and a good constitution, the case gets well, although the symptoms are severe. The inflammatory action in nervous diseases is the most grave. Mercury is more indicated in the congestive and inflammatory forms, while the biniodide, and the iodide potassium, are better for the exudative or plastic variety. The efficacy of the specific treatment will be accelerated by well-regulated regimen and adjuvants. If there is acute inflammation, leeches, and general anti-phlogistics; in chloro-anæmia and cachexy, use *tonics*, chalybeates, and sulphur; in neuralgia, rheumatism and palsy, atrophy, and anæsthesia, use electricity, as in other cases of these affections.

The visible phenomenon of *vaso-motor palsy*, first surmised by Schiff, and demonstrated by Brown-Sequard and Claude Bernard, has been recently corroborated, and still further illustrated, by Professor Montegaza, of Milan, in a publication entitled the *Gazzetta Medica Italiana*, of August, 1864. He divided certain spinal nerves, and watched the effect on the caliber of the blood-vessels, and the nutrition of the minute tissues, and the resulting hyperæsthesia. For this purpose he selected dogs and rabbits, and severed the great sciatic and crural nerves. The greatest care was taken to make the abstraction of spinal influence most thoroughly complete.

Thus it was shown that the section of the nerve-trunks causes not only a vaso-motor palsy, seen by dilatation of the vessels and other phenomena immediately traceable to this, but also that it gives rise to suppuration in deep-seated as well as superficial parts; also increasing very remarkably the growth and quantity of the connective tissue, while tissues of a higher order, such as the muscular, *diminish rapidly*, and finally disappear, in a manner that cannot be ascribed to the mere disease of palsied muscles. How very instructive are these facts! They reiterate, with unanswerable force, the lessons which a hundred other facts in medicine have taught, and still teach; but which are heeded only by the few. In defective nervous energy is the beginning of a great number of diseases. In this light we may more clearly comprehend the nature of very many organic, inflammatory, and cutaneous affections, as well as nervous affections; and the study of *nervo-paralytic hyperæmia*, and *anæmia*, with their concomitants, must command the attention more and more of every lover and practitioner of the healing art.

# CHAPTER VII.

## ANÆSTHESIA — DIMINISHED NERVE ACTION AND PARALYSIS.

CUTANEOUS ANÆSTHESIA is a diminution or total *loss of sensibility* in the skin. Hence it is a symptom, the opposite of hyperæsthesia. As under the *type* of this latter caption (in Chapter VI.) we treated of pains, perverted sensations, neuralgia, and *exalted nerve actions*, so here, under anæsthesia, we shall treat of palsies, and the various results of damaged and *diminished nerve-actions*.

First, of cutaneous anæsthesia itself. This usually occurs with loss of power in the underlying muscles; but it may occur alone, and independent of the power of motion. It is not the same as, nor is necessarily connected with, *muscular anæsthesia*, which is a loss of the consciousness of muscle movement. This skin deadness, numbness, no-sensation, is confined to the surface, and is a simple palsy of the skin nerves. It may occur in the face or fingers, hands or feet, or on some spot of the body or limbs; for it is usually a local malady. If not dependent on nerve or other organic lesion, Duchenne's method of *localized faradaization* is the sovereign remedy.

Anæsthesia is an abnormal sensation, or rather a want of sensation, manifested only in connection with external impressions; hence its term "*objective*," in contradistinction to those arising independently of external impressions, as vertigo and headache, which are termed "*subjective*." Loss of sensation may assume the form of inability to appreciate tactile impressions, or be only the loss of sensibility to pain; but both conditions frequently coexist; while we may also find the one without the other, and which may be, in any of these relations, more or less relatively complete. When it is partial, it is simply a benumbing sensation; when complete, it is a total insensi-

bility. It may appear in consequence of nervous dyspepsia, or as the evidence of an overworked, or otherwise exhausted nervous system; and often precedes the threatened attack of cerebral disease. Impaired sensation in spots, as on the tongue, or on portions of the skin, is to be suspected as the premonitory symptom of softening of the brain. Indeed it sometimes exists partially, as a numbness in the limbs and tips of the fingers, for months or years before the actual cerebral palsy occurs. It may also temporarily arise from slighter causes, or precede some cutaneous affection, or be the result of some poison, or simply result from deranged stomach.

Anæsthesia, without paralysis of motion, is not met with in the ordinary diseases of the spinal cord. So that if defective sensibility exists, and is owing to a spinal disorder, it is usually found in the lower extremities, and coexists with paralysis. If the impaired sensibility is of spinal origin, it is always indicative of the gray portion of the cord having been altered. But it may arise from reflex action, as from irritation of some viscera, or nerve of sensation. One side of the tongue, or nose, or face, may lose sensation from a rheumatic affection of the trigeminal nerve. But if this is complicated with disturbed functions of adjoining cerebral nerves, the cause is probably seated in the base of the brain.

The best test we have for the *degree*, *extent*, and *kind* of anæsthesia is electricity, or the *æsthesiometer*. The *blunt* points test for touch; the *sharp* points test for sensations of pain. Ice, heat, and pressure, are tests for tenderness or pain, superficial or deep-seated. (See *Faradaization.*)

### *General Palsy.*

When all the limbs, as well as the body, of an individual are deprived of motion, the affection is viewed as a *general palsy.* I have seen a case of catalepsy similate this; but then the sphincters were *un*affected, and the case remained in this state for but a short time. *General* palsy, strictly so speaking, may occur as a merely extended state of paraplegia. In these rare cases, voluntary motion alone may be lost, while sensibility still remains;

so may both be lost, but such cases are extremely rare. The origin of this sad condition is, probably, from some lesion of the spinal cord, or its membranes, situated high up, still *necessarily* below the origin of the pneumogastric nerves. Some general, special poison, as the *worara*, might cause it. Sir Benjamin Brodie very justly remarks that it is not to be supposed that *fatal* cases of palsy are always mere "functional diseases, simply *because we cannot find a lesion after death*. The mysterious and minute organization of the brain and spinal cord is by no means to be freely inspected by the naked eye. Nor even by the aid of a microscope can we trace but a little way. Some change of ultimate structure, some grand defect in the minute and intricate *ensemble* may exist, and yet be far too fine and deep to be perceptible to our senses." (See articles on *general palsy*.)

### *Catalepsy.*

*Catalepsy* is a suspension of the *will*. This strange complaint occurs as a paroxysm, which may be repeated. It is quite uncommon, yet might be mistaken for apoplexy or hysteria, or even death. The patient is statue-like. It is a sudden suspension of thought, sensibility, and of voluntary motion; during the continuance of which the muscles and limbs retain the exact position they happen to be placed in at its onset. The eyes are wide open, and the pupils, although dilated, *are very susceptible to the light;* there is no stertorous breathing, and no relaxation of muscles or limbs, and no paralysis, like apoplexy; for as soon as consciousness is restored, their power of movement fully returns. The pulse does not actually stop, but it is extremely feeble and frequent.

There is also a variety of catalepsy described by Dr. Watson as "*daymare*." The affected person is utterly incapable of moving or speaking, yet is cognizant of all that goes on around. It is a temporary suspension of will-power, and consequent deprivation of muscular power, *attended with remaining consciousness*.

Catalepsy, it will be remembered, is the almost only complete and general state of "palsy of *motion*" that can exist, without instant destruction of life. It rarely continues long, although it may recur from time to time. The fact is, this

## *Muscles of the Body, Anterior View.* Fig. 128.

(See opposite page.)

1. Frontal Portion of the Occipito-Frontalis.
2. Orbicularis Palpebrarum.
3. Levator Labii Superioris Alæque Nasi.
4. Zygomaticus Minor.
5. Zygomaticus Major.
6. Masseter.
7. Orbicularis Oris.
8. Depressor Labii Inferioris.
9. Platysma-Myoides.
10. Deltoid.
11. Pectoralis Major.
12. Axillary Portion of the Latissimus Dorsi.
13. Serratus Major Anticus.
14. Biceps Flexor Cubiti.
15. Anterior Portion of the Triceps Extensor Cubiti.
16. Supinator Radii Longus.
17. Pronator Radii Teres.
18. Extensor Carpi Radialis Longior.
19. Extensor Ossis Metacarpi Pollicis.
20. Annular Ligament at Wrist and Instep.
21. Palmar Fascia.
22. Obliquus Externus Abdominis.
23. Linea Alba.
24. Tensor Vaginæ Femoris.
25. Section of the Spermatic Cord.
26. Psoas Magnus Muscle.
27. Adductor Longus.
28. Sartorius.
29. Rectus Femoris.
30. Vastus Externus.
31. Vastus Internus.
32. Tendon Patellæ.
33. Gastrocnemius.
34. Tibialis Anticus.
35. Tibia.
36. Tendon of the Extensor Communis.

## *Muscles of the Body, Posterior View.* Fig. 129.

(See page 658.)

1. Temporalis.
2. Occipital Portion of the Occipito-Frontalis.
3. Complexus.
4. Splenius.
5. Masseter.
6. Sterno-Cleido-Mastoideus.
7. Trapezius.
8. Deltoid.
9. Infra-Spinatus.
10. Triceps Extensor.
11. Teres Minor.
12. Teres Major.
13. Tendinous Portion of the Triceps.
14. Anterior Edge of the Triceps.
15. Supinator Radii Longus.
16. Pronator Radii Teres.
17. Extensor Communis Digitorum.
18. Extensor Ossis Metacarpi Pollicis.
19. Extensor Communis Digitorum Tendons.
20. Elecranon, and Insertion of the Triceps.
21. Extensor Carpi Ulnaris.
22. Auricularis.
23. Extensor Communis.
24. Latissimus Dorsi.
25. Its Tendinous Origin.
26. Posterior Part of the Obliquus Externus.
27. Gluteus Medius.
28. Gluteus Magnus.
29. Biceps Flexor Cruris.
30. Semi-Tendinosis.
31. } Gastrocnemius.
32. }
33. Tendo Achillis.

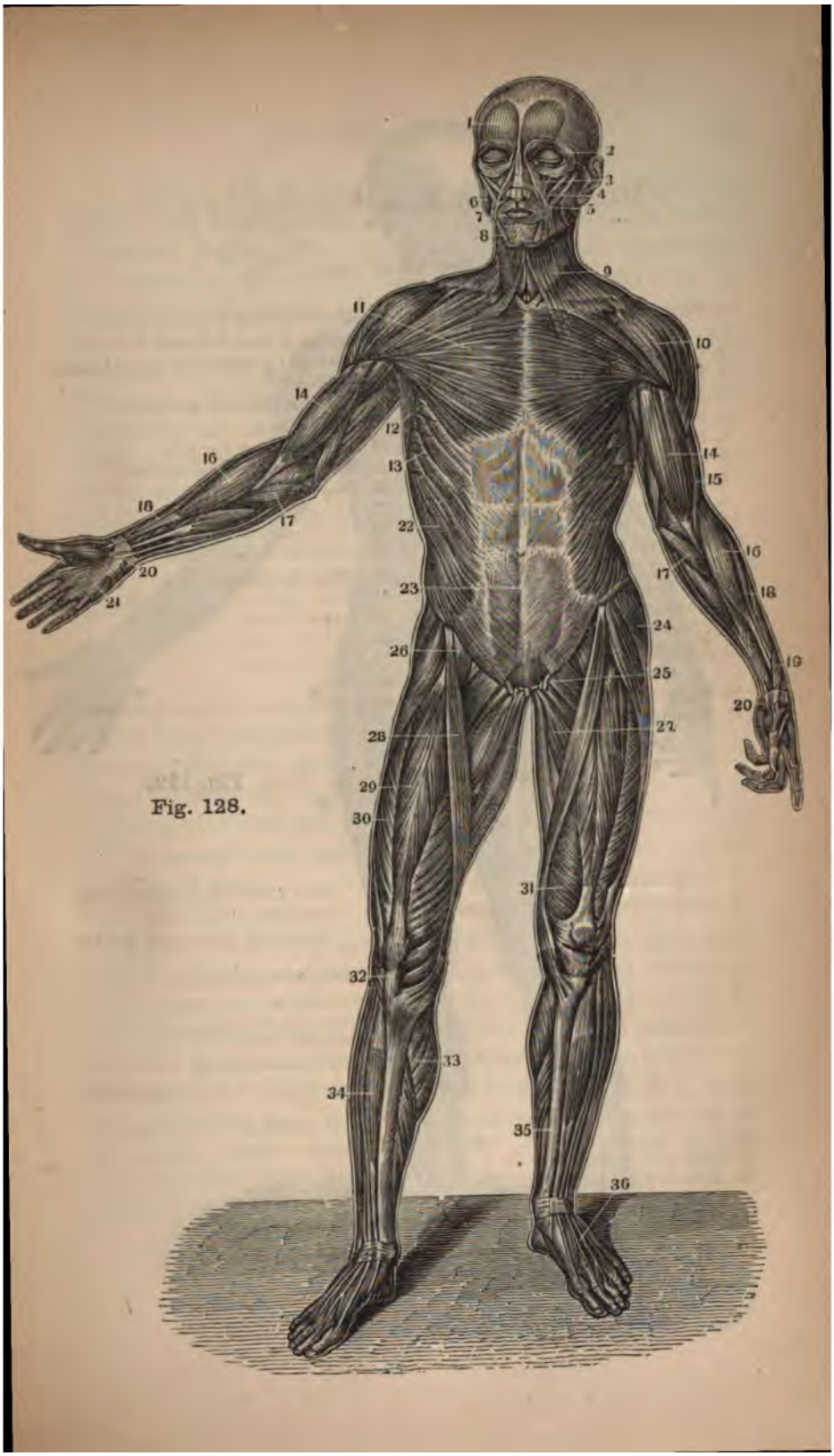

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36

Fig. 128.

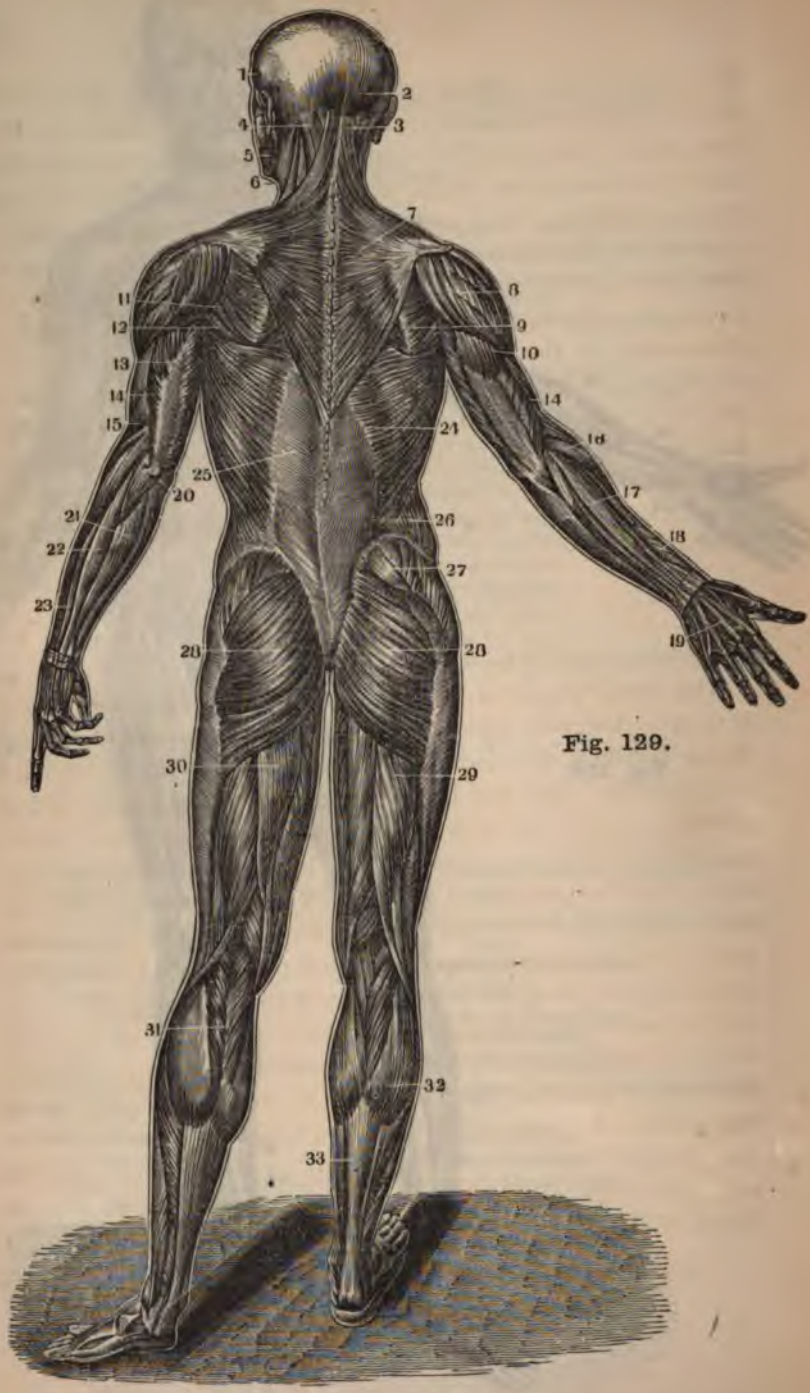

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33

Fig. 129.

*is a complete loss of the power of the will*, while there still remain both consciousness and sensation, but these in a very diminished degree. The sphincters are entirely unaffected; the *respiration* is so slight that it is perceived only with the greatest difficulty, and sometimes with uncertainty; the pulsations of the heart are extremely weak and frequent, or slow and irregular, and the pulse at the wrist may be too minute to be made out. Powerful currents of electro-magnetism, quickly alternated, or the sparks, or the Leyden jar shock of static electricity, is here called for, "to break the spell," and restore the dominion of the will. By these means, we usually succeed, and that quickly, except in some protracted cases of this "*suspended animation*," where perhaps it is wiser to proceed gently; as in attempting to raise a flame, we must always avoid putting out the taper.

## *Paralysis.*

The term "Paralysis," or "Palsy," (which mean the same,) is used to designate some degree of *loss of the power of motion.* There is, likewise, a paralysis of *sensation;* but this is termed "Anæsthesia," and will be treated of under that head. A loss of both sensation and motion frequently occurs together; but the paralysis of sentient nerves is more likely to be recovered from early, than the paralysis of motor nerves. They may not only occur together, but either may appear without the other; but then even, the simple paralysis of sensation (anæsthesia) is far more uniformly and promptly recovered from spontaneously, or by the help of treatment, than is the idiopathic or traumatic palsy of motor nerve and muscle fibre, which constitutes what we usually understand by the term *paralysis.* But we must ever bear in mind that palsy, like pain, *is but a symptom*, and not the essential disease itself. Says Dr. Todd,* "Non-medical people, and sometimes even medical men, are apt to speak of this affair as if the palsy constituted the whole essence of the malady;

* Clinical Lectures on Paralysis, Diseases of the Brain, &c., London, 1855.

but this is not the case. Palsy is an effect due to a cause, which cause itself is not always the essential disease." This is also true of most other diseases. "What then," he asks, "are the causes which may give rise to paralysis? These must be, either an affection of the nerve or nerves, whose power is destroyed in some part of their course; or from a morbid state of the *centre*, in which the given nerve or nerves are *implanted*, or with which they may be more or less directly connected. The nervous trunks themselves may be impaired, perhaps, in their nutrition, the centre being healthy; or they may have suffered some mechanical injury from violence or pressure. Thus they may become either *imperfect conductors* of the nervous message and force, or they may be rendered altogether incapable of *propagating* that force, or some portion of the *centre of volition* is the seat of a morbid process whereby the influence of the 'will' over certain parts is suspended, and thus the nerves of these parts receive no impulse at all from that centre, whether mental or physical; and although those parts may still be perfectly healthy in themselves, yet are they thus incapable of taking part in voluntary acts.

"Furthermore, whatever interferes materially with the *conducting* power of nerve-fibre, or the *generating* power of nerve vesicle, (gray matter,) will constitute a paralyzing lesion. In the first place, *poisoning* of the nervous matter will operate in this way: For instance, soak a portion of the nerve of a living animal in chloroform, or ether, or opium, and that nerve will fail to propagate the normal nervous force as long as the influence of the poison lasts. In a similar way, the poison of lead in the human system may paralyze, either by weakening the conducting or the generating power of the nervous matter. Poisons *formed in the living system* may operate in the same way; such as retained urinary or biliary principles, or the poisons of rheumatism, gout, &c.

"Secondly, any *morbid process* which greatly impairs the natural structure of nerve matter will paralyze. Thus inflammation will do this; so also will atrophy, or wasting from want of sufficient supplies of nutrient matter, as where the flow of

blood is lessened, or cut off. The opposite conditions of *hardening*, and so of red or white *softening*, of the nervous matter become paralyzing lesions from the same reason, viz., that they greatly impair or destroy the nerve structure.

"Thirdly, a *solution of continuity* of nerve fibre will paralyze. Cut a nerve across, and you have immediate palsy of the parts which the nerve supplies below the section. This solution of continuity from a final melting down of the fibres is, I have no doubt, the more frequent cause of sudden paralysis in cases of softening, or in cases of sanguineous effusion.

"Fourthly, *pressure* on a nerve or nervous centre will paralyze. Of this we have many proofs as regards nerves. A nerve, as for instance, included by a ligature, or compressed by a tumor, is paralyzed thereby. A fracture of the skull, *with depressed bone*, will paralyze, if the brain is sufficiently compressed. An apoplectic clot on the exterior of the brain paralyzes by compression; so also if a tumor is in its substance. It is by compression, probably, that congestion paralyzes; *but this latter cannot often* be regarded as a true paralyzing lesion.

*Meningitis* is a term expressing inflammation of the membranes of the brain, especially of the arachnoid and pia mater; the dura mater is very rarely inflamed, unless the morbid action is of syphilitic origin, or has extended from injured or diseased bones of the cranium. It is brought on by exposure, by prolonged depressing cares, by intense application to study, by an injury, or by disease of the head. The inflammation may be limited, mainly or wholly, to the coverings of the cervix portion of the brain, or in other cases to the base. When limited to the base of the brain, it is said to be attended with remissions in the delirium by the coexistence of spasmodic symptoms, and with early profound coma.

There are two distinct stages in the acute form; in the first there is intense headache, hard and frequent pulse, vomiting, fever, injected eyes, irregular respiration, obstinate constipation, soon attended with delirium and convulsions. The second stage is known by the evident ebbing of the vital forces; the pupils are dilated, the pulse is become feeble, the extremities cold, in-

voluntary passages, loss of mind and sensibility, and complete coma or collapse — the whole occupying about seven days. Of course no electricity is to be employed in such cases.

*Cerebritis.* — There is very little difference between inflammation of the brain tissue and inflammation of the meninges of the brain. In truth, according to Da Costa, what we commonly call meningitis is often also cerebritis; for the diseased process extends very rapidly from the tissues of the brain to the adjacent cerebral substance. Therefore we may suspect it, when the sense of vision or of hearing is *suddenly* perverted; and if occurring with other symptoms of inflammation in the head; if the convulsions, the agitations of the limbs, the tremors, are very marked; if they occur chiefly upon one side; and if coma succeeds rapidly to the period of excitement, and is accompanied or is preceded by one-sided palsy.

Finally, we may be sometimes much perplexed to know if the palsy is the result of commencing disease in the brain. Da Costa, in his excellent work on Diagnosis, page 63, says, in some cases "the cerebral symptoms may not be very marked, or be so contradictory as to afford no real help in diagnosis. We may have nothing to fall back upon but our knowledge of the anatomy and physiology of the nervous system; and if here we discover that the palsy affects muscles that are supplied by different nerves, and such as have no communication with each other, we may set down the complaint as having a central origin."

*Head-symptoms from Acute Rheumatism.* — In rheumatic fever, after a week or so, there may occur restlessness, headache, and delirium, sometimes so violent, or followed by coma, that it is liable to be mistaken for inflammation of brain, or meningitis, and to mislead the physician, causing him to overlook the rheumatism, or to regard it lightly, compared with the head symptoms. There is no metastasis of the disease to the head, but these symptoms *prognosticate* the setting in of pneumonia, or of inflammation of the membranes of the heart, and arise, probably, from the altered condition of the blood.

### *Brain Palsy — Hemiplegia.*

*Hemiplegia* is the term generally used to denote paralysis of one side, extending to both the upper and lower extremities; and *usually* the lesion in the brain, when this is the cause, is on the opposite side to the seat of the manifested palsy. When the lower extremity of one side and the upper extremity of the opposite side are affected at the same time, then the case is said to be a *crossed* palsy. These cases, however, are rare.

Hemiplegia is the result of cerebral disease, in a vast majority of cases. But it *may* be rheumatic, hysteric, or spinal. It may involve nearly all the voluntary muscles of one side of the body and limbs; but it generally involves only the muscles of the upper and lower limbs of one side, as also those of one side of the face, which is usually on the same side; but sometimes this latter appears on the other side. The patient is prostrated from the attack, (of apoplexy or red softening,) if it comes on suddenly, as it usually does; the arm and leg being more or less helpless, and usually completely so. The one cheek hangs pouting; the mouth is drawn towards the healthy side, because the paralyzed muscles on the other side are now powerless to resist it; the tongue is usually protruded with difficulty, catching between the teeth, or is slowly and partially pushed out towards the affected side, and the articulation is imperfect or totally lost. But if the patient can close both eyes, — that is, the eye also of the palsied side, — this, occurring *with* the face palsy, characterizes the case as of cerebral origin.

The condition of the muscles thus paralyzed is very various. In most cases they are diminished in warmth, are relaxed, and with diminished sensation, or complete anæsthesia. In other cases the muscles are too warm, red, shrunk, rigid, and *contracted*, with pains and hyperæsthesia; and at times, perhaps, becoming agitated with cramps and convulsive movements — reflex motions. There is also a derangement of the eyes, a decay of the mental faculties, and other signs of a brain lesion. In the worst cases, it is attended with a fixed pain in some part of the head; usually back of the ear on the opposite side from the

palsied limbs. The apoplexy, disease, or other injury in the brain, is always on the opposite side from the palsy, if the lesion, as it almost always is, be seated *above* the point of decussation of the pyramidal columns of the medulla oblongata.

But in some rare instances this lesion involves, by compression or otherwise, both the right and left sides of the brain, equally or unequally; in such a case, the palsy will also be double; i. e., on both sides of the body — equally, or relatively, more on the one side than on the other. A lesion at, or *on a level* with this decussation, produces double-sided, or, in other words, general palsy. A lesion *below* the decussation gives rise to a paralysis only on one side, but that on the same side with the lesion. If motion be very gravely impaired, we may reasonably conclude that the lesion, or morbid process, involves the corpus striatum.

If sensation is greatly impaired, or destroyed, the optic thalamus is involved; indeed, where the thalamus is affected, the striatum is so contiguous that it also is usually involved. In most cases of central palsy, a singular reflex twitching of the affected muscles can be readily produced by certain stimuli; as the sudden touch to them of electricity, ice, or heat; or by tickling the soles of the feet, or a smart blow of the hand on the rectus muscle of the thigh. If the attack of apoplexy is attended with profound and prolonged coma, and if with this there is early and persistent tonic contraction of the palsied muscles, there is probably a ventricular hemorrhage; i. e., the effusion is into the brain ventricles.

If the apoplexy or tumor affect the *tuber annulare* below the place of crossing of the fibres of the facial nerve, it will cause paralysis of the face on the one side, and of the limbs on the other. If the lesion involve a spot *above* the crossing of the facial nerve fibres, then the face and limbs are all paralyzed on the same side together, and that opposite to the lesion in the brain. These points have been carefully studied and explained by Gubler.

A young woman had severe headache for some time on the right side of the head, with distressing vomiting; and after a few days, with slight numbness in the left hand and foot, as also

great intolerance of light. Her intellect appeared clear, but soon after she became blind, then delirious, and at length died in convulsions. Disease was found in the right hemisphere.

In two cases of hemiplegia, from disease of the *crus cerebri*, in which the third, or *motor oculi* was involved, this nerve was paralyzed on the same side with the lesion, while the limbs were paralyzed on the opposite side. In disease of one side of the *pons verolii*, the *portio dura* is paralyzed on the same side, the limbs on the opposite side.

*Apoplexy* is, in other words, a cerebral hemorrhage, a coma, a hemiplegia. In very many instances the attack is *preceded* by great depression of spirits, by periods of loss of memory, by illusions, by vitiated perceptions, by vertigo, by heaviness and confusion of thought, by strange sensations in the head, by *continuous pain* in the head, or slight convulsions. Apoplexy, sometimes, has no prelude. It is recognized by *coma*, (which it is,) coming on rapidly, from compression of the brain by extravasated blood; far more rarely from turgescence of the vessels, or from an effusion of serum.

The attack is generally very sudden; the patient falls to the ground bereft of all consciousness, and lies as if in a deep sleep, breathing laboriously and noisily; each snoring inspiration being followed by a flapping of the lips and cheeks at the beginning of each expiration. The eyes are half open, with the pupils insensible to light, being either contracted or dilated; there is difficulty of deglutition, and the pulse may be slow, full, or at times irregular, while all thought, all sensation, and all volition, are suspended, or obliterated.

In the course of a few hours, or days, unless the lesion be very great, the patient begins to recover from the shock, if he ever does, and apparently wakes up gradually, so that the intellect resumes more or less control, while the functions of the body are more tardily restored to their respective natural condition. But there is one vastly important symptom remaining, after all, viz., *hemiplegia*. This *sequel* symptom of apoplexy may be recovered from sooner or later, or in other instances it may remain for years, or for life.

*Acute Red Softening of the Brain.* — This may give rise to apoplexy, with symptoms so similar to those of cerebral hemorrhage, that, according to Da Costa, a differential diagnosis is impossible. Especially is this so when the disease is manifested suddenly, which happens in nearly one half of these cases. In those of a more gradual origin from red softening, a feeling of numbness, diminished memory, irritability of temper, some impairment of motion, and a vacant dull look, are observable for some time before the attack. In some instances delirium just precedes the loss of consciousness. This loss may be perfect; in another case imperfect, in another entirely wanting, — for the patient may become paralyzed from red softening without losing his consciousness. *And this palsy may be, and often is, attended with hyperæsthesia, and with rigidity of the limbs.* A significant sign of acute softening, is, an increased secretion from the mouth and eyes. The prognosis must be unfavorable, for the mind will remain enfeebled, and there may be occasional convulsions, and there is otherwise but slight amelioration; while in the case of cerebral hemorrhage, after the shock is over, a gradual improvement takes place, which is very obvious as regards the mental faculties, and the power of articulation.

*Sudden and Extensive Paralysis without Coma*, is usually owing to softening of the brain, which suddenly and extensively gives way; or it may be the result of hemorrhage into the spinal canal. If the latter, it will almost invariably be double, i. e., on both sides, and attended with severe spinal pains; and if the extravasation is into the meninges of the cord, there will also be tonic spasms, like those of tetanus.

*Syncope* is a fainting; and it differs from *asphyxia*, from *apoplexy*, or *epilepsy*. In all three, there is a sudden loss of consciousness. In syncope or fainting, there is a failure of circulation; the heart and the brain show it first, by suspension of thought and volition, and *almost a suspension of pulse*; presenting a death-like pallor of the face, and relaxation of the entire frame, but with quiet respiration; all of which is of but short duration. Asphyxia, on the contrary, is attended with distressed and embarrassed breathing; showing bluish lips, turgid and livid face, which, if continued, is followed by shuddering,

convulsions, and the loss of consciousness. In apoplexy, there is the full pulse, the snoring and blowing respiration, with loss of consciousness. Epilepsy differs from it still more by the piercing cry, the fearful muscular struggle, stiffness of limbs, and convulsive movements, with loss of consciousness.

*Syncope*, when induced by a blow on the stomach, also other cases of it, are thus treated of by Dr. Brown-Sequard: "Experiments upon animals have shown me that in these cases the syncope is produced by a *reflex* action through the abdominal sympathetic ganglions, the spinal cord, and medulla oblongata, and then, finally, through the par vagum. I have often and often tried the experiment on animals, and of crushing the ganglions of the sympathetic in the abdomen. In some it arrested the heart's action, in others only diminished it temporarily, while in others there was almost no effect produced. If the par vagum is first cut, the crushing produces no effect, showing that the influence is *via* the par vagum. Now, in all those cases in which the heart is stopped, whether by the cause above assigned, or by any other cause, such as drinking very cold water when very warm, or by an emotion, &c., — in any of those cases of *reflex syncope*, when the patients are on the verge of death, and would almost surely die if nothing were done for their immediate relief, — in such conditions there is one means of restoring life, which I have found by experiments on animals to be of the utmost importance; even when the action of the heart had quite stopped, I have been able, by simply pressing on the sternum, and by giving a hard push to the heart, to make it beat again; and after repetitions, to make it resume its regular actions. But this is not all. If you add to these sudden repeated quick pressures, another, — if you stop his breathing altogether for a quarter or half minute, just as if you were trying to kill him by suffocation, — you revive him. By producing a state of asphyxia for about a half minute, the patient may be saved; he will have a struggle, and come out of it very quickly."

*Vertigo* is a transitory feeling of swimming of the head. There is a seeming movement of surrounding objects, and a sense of falling over. It arises from disturbed circulation of blood in the head, from disease there, or elsewhere, or from

mere mental or emotional influence. It may occur, then, in any disorder of the brain, and may be recognized as such, in part by the absence of other causes which might induce the dizziness; and in part by its being attended with other illusions of sensations, and with headache and other signs of encephalic disturbance. Or it may be, and often is, symptomatic of disease of the heart, or liver, or kidneys, stomach, bowels, or blood; but especially is it a symptom of extreme exhaustion of the nervous system.

There are various unnatural sensations that may come under this head, such as a feeling of momentary unconsciousness, without dizziness; a sensation in the head of tightness, fulness, or weight. There may be a sensation of "*rush of blood to the head*," but it is a mere sensation, and not a rush; there may be ocular spectra, and other false perceptions of many kinds. Vertigo, in brain affections, however, is most usually *objective* in character, i. e., to the patient; surrounding objects appear to move, not he himself. While in *subjective* vertigo, resulting so frequently from the mere sympathetic disturbance of the brain, from causes without, he himself seems to move, and not the objects; and mere closing the eyes relieves it.

There is a kind of vertigo that is very short and severe, occurring at uncertain times; while at work or while in bed; leaving the mind stupefied and the head heavy for a little time. It is a dangerous type, almost a *petit mal*, and often the precursor of epilepsy, or other convulsive disease.

*Head-symptoms, from obstruction of the cerebral arteries*, may be *suspected*, if the patient be, or has of late been, laboring under an acute or sub-acute endocarditis; and all the more if several incomplete attacks of apoplectic-like symptoms occur within a short time of each other, before a perfect and generally fatal comatose condition sets in, from which the patient does not rally. The resulting paralysis is hemiplegic, and the face palsy is on the same side. These apparently apoplectic symptoms may or may not be attended with loss of consciousness, and more frequently are not; but when there is loss, it is usually slight, and of short duration; while the palsy is sometimes speedily followed by gangrene in the extremities, or is attended with obstruction, from the same cause, of the kidney;

also of the spleen, with tenderness on the splenic region. The most usual lodgment of this blood-moss, or *emboli*, as it is termed, is, according to Virchow, in the constrained artery at the *fossa of Sylvius*, or in some of the nine cerebral fossæ. Sometimes, the clot is not washed so far into the brain, but lodges in one of the brain arteries, and from thence the *thrombosis* may form as far back or down as the common carotid. It is affirmed that this may be recognized by the absence of pulsation in the carotid artery of the affected side, by its tense, pulseless, cordy feel; and the case will not keep us long in suspense, for it soon proves fatal. (See *Embolism.*)

It is believed and now taught by Dr. E. Brown-Sequard that *the symptoms (paralysis, &c.) of brain disease are generally due to a reflex action.* We have heretofore been taught to view the symptoms of disease of the brain proper, i. e., in the cerebral lobes, as an injury there; producing paralysis by striking the organ of the *will;* that there is a direct paralysis of the will power, at least for that part of the body which is paralyzed, and that if other symptoms occur, they are due also to the loss of function of the part altered in the brain, or to pressure upon neighboring parts. We are all familiar with the great variety of symptoms presented by brain disease; so may there be grave disease in the substance of the brain proper without any symptoms. He shows that the facial nerve may be paralyzed by lesion in the anterior or posterior brain lobes; that you will find for a tumor in one and the same part of the brain, there is, in some cases, no symptom at all produced, while in other cases you may find any symptom whatever. Even in the same individual, with the one same persistent disease, you will often have a great change in the symptoms; he may be paralyzed to-day; another day he may not. The only explanation he ventures to offer of these phenomena is, that they come under the class of effects produced by *reflex action.*

*Sun-stroke.* — An attack of this affection, when severe, and threatening to prove fatal, is usually ushered in by sudden pain in the head. There are great weakness, præcordial distress, vertigo, insensibility. This last symptom occurs so suddenly that it gives it the term *sun-stroke.* The insensibility deepens into

coma, and there is dilatation of the pupils, while the pulse is both full and frequent. The skin and the mucous membranes, wherever they can be seen, are red, dry, and hot, and the respirations are hurried, and there is excessive thirst. Such is the first stage, which occupies only about four hours; then comes the second.

The respiration becomes stertorous, with moanings; the pulse is now feeble, but frequent; the pupils in some cases contracted, in others dilated; the skin is cool, while the mucous membranes become livid. Death may take place suddenly in convulsions; or life may gradually disappear, with occasional gasping respirations, and tracheal râles. When there are contracted pupils, with moaning respirations *from the first*, the case will be likely to prove speedily fatal. In milder and more hopeful cases the second stage is entirely wanting, so that the stupor is only short; but in these latter cases there is excessive thirst, and heart distress, with difficult articulation and deglutition.

We may know a case of sun-stroke from apoplexy by the fact that, in the former, the pulse is not slow and full, but usually feeble; there is more difficulty in swallowing, but a less snoring respiration, and the coma is shorter. The after symptoms show us that in apoplexy there is paralysis; in sun-stroke only feebleness, no paralysis; in the former, no marked persistent headache; in the latter, headache that is more or less chronic, and aggravated by walking in the sun, and perhaps for months attended with signs of nervous exhaustion. But there are cases, according to Da Costa, in which the abnormal symptoms of sun-stroke come on gradually; the patient at no time becomes quite insensible. I have seen several of this kind—officers sent home from the army of the Potomac. The chief symptoms are, intense headache, nausea, prostration, and inability to perform any work requiring continuous action or attention. All these signs appear after protracted exposure to the sun's heat, and such cases mend but very tardily. In truth, in the slowly developed disorder, the subsequent nervous exhaustion, and the paroxysms of headache, seem to be much more persistent than in the more sudden and apparently more violent attack of sun-stroke. Among the sequelæ of these apparently incomplete

attacks are irritability of the bladder, incontinence of urine, and irregular action of the heart. But nothing is as striking as the loss of mental and bodily energy, and loss of power of endurance.

*General Cerebral Palsy*, partial or incomplete, as also *spinal exhaustion*, and partial palsy, are sometimes produced by repeated nervous excitements and exhaustion, even in the most healthy constitutions. Venereal excess, i. e., frequent repetitions of the indulgence, also self-excitant, and self-pollution, are either of them most powerful causes, leading early or ultimately to this result. Good Hufeland says, "It is proved beyond all doubt that nothing renders the mind of a young person so incapable of noble and exalted sensations and actions, destroys so much all its firmness and powers, and relaxes the whole being below the natural capacity of the individual, as does this sort of dissipation." To my own mind it is a prodigious squander of talents; it is to every person a ruinously costly pleasure, that pays only in pain and shame, and the sooner it is utterly let alone, and *persistently banished from the mind*, the better.

It is not too much to affirm, — indeed I know, — that a state bordering on dementia has often been produced by lawful or unlawful venereal *excesses;* and still more frequently by the continuous habit of *solitary vice*. M. Esquirol says that "immoral habits are very frequently the cause of that deplorable species of paralysis, which becomes complicated with dementia and monomania."

It may appear to some remarkable that sexual excitements should have so pernicious an effect, for the nerves of the genital organs are by no means large, their origin is remote from the brain, and the loss of excreted matter can hardly account for so serious a drain on the nerve centres. One way we may account for the remarkable nervous collapse which so surely follows abuse of the generative faculty, is, that owing to the intimate commissural connection between the lumbar enlargement of the cord, where the pudic nerves are implanted, and the superior and nobler nervous centres, the intense excitations and nervous shocks, self-produced and persisted in, *uses up the whole chain of ganglionic force* together, so that the depression is as great

as the previous excitation. Besides, we must remember that this is a mental sin, as well as a physiological transgression. The penalty must be severe. It proves to be double. Surely "*the ways of the transgressor are hard.*" God knows it. The physician sees it. The patient must be timely convinced of it, or will learn it to his sorrow and ruin if he persists in it.

*The character* of the paralyzing lesion, then, can only be arrived at by a careful scrutiny of all the facts in the case. "A sudden paralysis, occurring simultaneously with coma, almost always has its origin in an *apoplectic* effusion; a sudden paralysis without coma is generally due to a rapid giving way of a softened brain. A gradual development of palsy indicates some chronic cerebral disorder, such as softening, a tumor, or any affection compressing the nervous substance. We may also gain much knowledge by carefully exploring the organs of circulation and the kidneys. Thus, a paralysis found to be associated with a cardiac malady, or with a diseased state of the arteries, is, in all likelihood, owing to softening, to an apoplectic effusion in the brain, or, as happens in rare cases, to a stopping up of one of the cerebral arteries with a mass of coagulated fibrine. When the kidneys are seriously disordered, it is not unreasonable to suppose that the hemiplegia has been caused by some chronic disease of the brain, the result of the altered nutrition, *produced* by the ill-purified blood.*

As a further clew to the character of the paralyzing lesion, Dr. B. Todd has shown that when the paralyzed limbs exhibit a rigid state of the muscles, appearing from the moment of, or soon after the attack, we may assume that the lesion is of an irritative character, such as an inflammation, or a compression of healthy brain tissue, by an apoplectic clot, or by an accumulation of puriform fluid in the sub-arachnoid spaces. When this rigid muscular contraction of some of the flexors does not take place until *late* in the complaint, and then becomes associated with wasting of the muscles, it may be presumed to be caused by an increasing irritation, as from an attempt at cicatrization. When the muscles are flaccid and relaxed, and there is, for

* Da Costa on Medical Diagnosis, p. 156.

instance, no resistance to flexing the fore-arm upon the arm, or the leg upon the thigh, we may conclude the lesion to be of a depressing character, such as *white softening of the brain*, with or without rupture of the blood-vessels.

This latter constitutes the large class of these cases that can be so much and so speedily benefited by electricity, if applied at a proper time and in a judicious manner. In these cases, where there is resolution of the muscles, — that is, where shock passes off without leaving total palsy, or contractions, or other signs of continuous morbid central influence, the galvanic excitability of the paralyzed limbs is far less than those of the sound side. These are suitable for this treatment. But where there is early rigidity, it is decidedly increased. These are not to be treated.

Paralysis from cerebral hemorrhage, (apoplexy,) it is true, generally shows as a *hemiplegia;* but it is also true that it may be *paraplegic;* and from slighter attacks it may be but partial, and quite *local*, as in a portion of an extremity, affecting only one of the fingers or toes; or in one side of the face, or only in one side of the tongue, or simply about one eye. But these little symptoms are very significant. It is well known that the resulting palsy, great or small, is in part caused by *shock*, an undue impression on the great nerve centre, produced by rushes of blood from various causes, and not altogether the result of a destructive process, or a local, fixed compression of a paralyzing lesion. Now so much of the palsy as is due to shock will recover of itself, as it gradually does, within a few hours or days; but the remaining palsy may continue as long as life, unless aided by electricity or other judicious means.

It is my experience, however, that no attempt should be made for active and thorough use of electricity in any of the graver cases for some considerable time after the attack, not until there is reason to suppose the effused blood has been absorbed, the ruptured little blood-vessels are healed, and an unirritating cyst, or a favorable cicatrix, only remains, that is entirely without inflammatory action. As electricity acts also by producing a change of polarity in the nerve-trunks and their centres, as well as through catalysis and electrolysis in fasciæ and muscular tis-

sues, together with considerable stimulation at and about the root of the nerves, (about the brain lesion,) it is obvious that it can be of no use while the palsy still depends upon vascular congestion, inflammation, or organic disease of brain or spinal cord, or of the nerve-cords.

*Exhaustion of Brain-power* is an affection I have often seen, more particularly among educated, literary, and professional men; among our inventors, editors, college professors, and other hard thinkers. There is discovered at first an inability to read or write very long, and a decided impairment of memory, although the power of thought and judgment still remains perfect. He soon fatigues, mentally and bodily. He is somewhat dyspeptic, although he may not have lost flesh. But he is troubled with weak and irregular action of the heart, ringing in the ears, and he has sleepless nights. He cannot bear much exercise, and in most cases there is a frequent desire to urinate. He is convinced that he is *almost* a sick man; for although he can still attend to business, and give his attention to any subject for a time, he soon tires of it, and from very fatigue is obliged to quit. Evidently from over-use the nutrition of the brain is deteriorated; and it is possible, yes, very probable, that the uninterrupted continuance of mental toil and anxiety would have led to fatal softening. Such a case differs in symptoms from actual brain softening by the absence of, or at least by the far less marked headache, by the slight impairment of intelligence, and by the non-occurrence of spasms, or actual paralysis. In a word, such a case, with such symptoms, is doubtless in the incipient stage of that serious cerebral disease termed *softening of the brain*. But if at once taken from business, for rest and proper treatment, or with change of climate for a few months, these cases entirely recover.

*Chronic Softening of the Brain.* — In a word, this is a malady that is characterized by *gradual impairment of the mental faculties, with some degree of paralysis;* or rather with here and there a spot of partial paralysis. The pathology, when seen, is clear and decisive; but the symptoms, seen or unseen, are not so positively reliable. Dr. Da Costa, one of our best modern authorities, says there are in truth no positive symptoms which

enable us to declare, without hesitation, that we are, or are not, dealing with chronic softening of the brain; yet there are a very large number of cases which exhibit certain groups of pretty uniform manifestations, which permit us to recognize the disease with considerable certainty. I will here quote him.

There are two main forms of brain softening, "the red and the white. The former is inflammatory, and runs an acute course, with symptoms closely simulating apoplexy, or with signs like those of the chronic malady, only differing in their intensity and short duration. The second kind is chiefly dependent upon a change in the nutrition of the brain, and is often attended with a diseased condition of the cerebral arteries; but it may rather be caused or attended by an inflammatory exudation infiltrated among the nervous pulp. These are briefly its early symptoms: gradual impairment of intelligence, weakening of memory, headache, vertigo, muscular debility, cutaneous hyperæsthesia, formication, and numbness; slight or local paralysis, as of one side of the mouth, or of one eyelid; defective articulation, great irritability of temper, nausea or vomiting, extreme sensitiveness to sounds, and subject to painful feelings in various parts of the body. As the local mischief advances, the paralysis extends and increases, generally in the hemiplegic form; spasms, either tonic or clonic, or epileptic convulsions occur; the mental decay proceeds steadily on, showing it sometimes by a constant repetition of the same action, or of the same phase. The more acute and rapid the symptoms, the greater the likelihood of their being due to an inflammatory lesion; and in young subjects this probability becomes almost a certainty. A latency of the affection, its slow and gradual manifestation, its existence in persons advanced in life, and where we may suspect degeneration of the coats of the arteries, are facts which justify the conclusion that this case is owing to impaired nutrition, and not to brain inflammation."

In cases of brain *softening*, too, we find the headache is much more violent and paroxysmal — not dull, nor of steady intensity; and the intelligence remains for a long time unimpaired, with the exception, perhaps, of a weakening of the memory. Remissions, or intervals of apparent improvement, occur; but such

are more perfect, and of longer duration from tumor, than with softening.

*Progressive brain-palsy* is usually but the advanced stage of brain exhaustion. In the lighter or milder forms there is simply a state of more or less enfeeblement of the functional power of the brain, as from extreme exertion of body or mind. Thus we may see brain fatigue, brain enfeeblement, extreme or gradually increasing *brain-palsy*. If from fatigue alone, rest and tonics will soon restore the brain function; but if from overwhelming shock, or from protracted or repeated nervous exhaustions, repose alone may not restore. The use of tobacco, or dissipation, or secret habits, may induce it. Actual *dementia* may be the result. It may involve any, many, or all the mental faculties. So we may see cases of varying degrees of brain-palsy, according to the temperament, and the cause involving the intellectual, the voluntary motor, or the sensory faculties, or all of them. The grand characteristic of these cases is (if considerably severe) *nervous debility with irritability*.

*Case of K.* A young man, not twenty-five, came to me complaining of a *sense* of stupidness, and yet a nervousness all over; a sense of weight on the top of his head, and a sleepiness so that he was prone to go to sleep wherever still. These symptoms had been increasing upon him. He said he felt often as if his head did not belong to him; and when he read, as if his thoughts were a great way off; and he was subject to giddiness. He was still in good flesh, had a good appetite, and functions in fair order, excepting slow bowels. It was evidently a case of impaired cerebral function *from nervous exhaustions*. His habits were corrected; prescribed *formulæ* numbers 4 and 8; electricity was administered twice a week over spine and loins. In a few months he was quite restored. (See Rule 14, p. 469.)

*Insanity-with-palsy, or "Paresis."* — This is an insidious, progressive, and fatal malady. *Slight* paralytic symptoms are usually first to be observed in these cases; but if not, this affection is recognized by its gradually progressive, *double* character; and thus it is known from other palsies, and from other mental disorders. It is characterized, in many cases, by the early inability to articulate distinctly; by impairment of memory and loco-

motion; by the changed mind and countenance, and by the perversion of the mental and moral faculties, amounting to extreme oddity, or else insanity. It is a peculiar palsy; for at least during the earlier stages of the disease there is little actual palsy, but rather a want of control over mind, muscles, and body. The patient staggers or sways; there is dementia, thickness of speech, and enfeebled nerves and muscles generally. All this is progressive; for soon the speech is hesitating, disorderly, and indistinct, until scarcely a sentence or word can be understood. Finally the muscular movements gradually grow worse, so that the patient cannot walk, or even rise, without assistance. In some this is postponed for months; in others for years. A painful contraction of some muscles in the body or limbs will set in, or convulsive attacks, or pulmonary troubles, diarrhœa, or coma closes the scene. But we must more closely examine the different phases of this obscure malady.

These cases do not, then, present absolute and complete loss of power and sensation. All parts of the body are not at once attacked with palsy, although, as the affection progresses, organs and limbs become gradually implicated, which were not affected in the commencement of it, until many or even every function and limb is more or less involved. We have heretofore been taught to find "a peculiar difficulty of articulation, unstable or staggering gait, extravagant ideas," &c., as limited characteristics of this disease; but all this, and this only, may not be developed in an early stage, or may never be manifested in the given case. The insane are liable to all forms of paralysis, in common with other persons; but they also have a *peculiar liability* to disease of parts within the cranium, that is made manifest by this peculiar progressive palsy. In some cases the failing of speech occurs early — is, indeed, the first symptom; while in others it appears only in a more advanced period, or not at all. There is usually the peculiar delusion of wealth, or the most terrible delusions of poverty, or other harassing troubles.

Before even any paralytic symptoms are manifested, there usually appears first definite but slight indications of the coming affection, which, if discovered in time, and properly treated, are

capable of arrest; although a little later, when the disease has gone on to full development, there is little or no hope of averting the fatal issue. Some change in the temper and manner of the patient, together with a failure of memory, unaccountable conduct, and disregard of order or prudence, sets the friends to thinking that the mental powers are undergoing a change; and this is the time for successful treatment. Failure of memory is one of the earliest features of this disease; and when observed, together with *altered manner and conduct*, in a person forty and over, it should be watched carefully, on account of his affairs, as well as for his life. The course of the disease is not uniform; but the most diagnostic symptom is the imperfect articulation, from loss of power in the muscles of the lips; or in some the tongue is most at fault; in others the difficulty seems to be nearer the throat; later in the disease scarcely a word can be spoken. In ordinary stammering the will-power is at fault; in this affection it is a loss of muscle-power. Persons so afflicted are usually hopeful, patient, and submissive; and not only so, they are often in a state of ecstasy or exalted happiness, and joyful satisfaction of their insane convictions of wealth, health, and importance; while their true state shows the most deplorable infirmity and helplessness.

Persons not familiar with "the progress of mental decay under these particular circumstances," says Dr. Wood, "will maintain that this is not insanity, and insist that there is no reason to interfere with the liberty of the patient, while this step is quite essential to any prospect of arresting the disease. The freedom to pursue his own plans and carry out his peculiar views, keeps up a pernicious excitement that is exactly calculated to render futile any and every treatment. To reason with him is the worst thing possible; for the more he is opposed, the more he labors to prove that he is right and sane. He should be promptly placed under control, in the early stage of the affection, and the cure is quite possible."

Later in this affection there is an increasing difficulty in regulating the movement of the limbs, and appreciating the distance of objects; the patient rarely puts forth his hand to the exact spot he aims at, and his hold is liable to be uncertain or

spasmodic. Convulsions finally set in, of shorter or longer duration, which often occur with a peculiar blowing or explosive expiration, which is characteristic.

Organic lesion of the nervous centre in general palsy of the insane, is shown by M. Joire. There is a development on the anterior and inferior surface of the fourth ventricle, like the *cutis anserina*. This is in proportion to the duration of the disease. In patients who die at an early stage, the granulations are numerous and small, like grains of sand. In cases of longer standing, the projections are large, whitish, or transparent, and so firm as to feel like rugosities. This lesion is generally attended with more or less dropsy of the ventricles and meninges; and it is sometimes attended with softening of the superficial layers of cerebral substance, which is easily raised by the handle of the scalpel. Hence we see the importance of diligent treatment for recent cases; while the older cases must necessarily be beyond the reach of skill.

*Paresis* somewhat resembles chronic alcoholism; but may be known by the history of the patient, and of the starting points of the two affections. General paresis begins from a morbid process in the delicate membranes of the brain, while chronic alcoholism proceeds from general intoxication or poisoning. In the former, the psychical symptoms first present — the degeneration of the mind leading the degeneration of the body; but I have seen some marked exceptions to this rule. In the latter, the paralytic symptoms are first seen; are symmetrical, or nearly so; the general intoxication of the body leading on to the mental degeneration.

General *paresis* has been confounded with paralysis from muscular atrophy. In both these diseases we have progressive palsy; but in the former the seat of the disease is in the brain; in the latter it is in the muscles or the muscle nerves. The former, when under the influence of their delirium, can rave and use their muscles very violently; but the latter do not rave, and cannot if they would, for their muscles are not capable of violence. Rokitansky, of the Vienna school, was the first to demonstrate the anatomical changes in these cases of *insanity-with-palsy;* but Dr. Salomon, of Sweden, being at the head of an

excellent asylum, has given the most accurate and full description of this most insidious and melancholy disease, to which human beings are liable.

This double disease — *premature decay of mind and body* — is first manifested, then, by unusual irritability, melancholy, indifference, or perversion of the moral faculties, indecision; yielding readily to outward circumstances, morbid restlessness, ennui, *thickness of speech*, indistinctness of articulation, and uncertainty of gait and step. There may be seen, in most cases, involuntary twitchings in the muscles of the face, particularly about the angles of the mouth and eyes, and *in the upper lip*. Such is the first phenomenon, the first stage. Unless the disease be arrested in the very incipient stage, — and much can be done simply by early to bed and early rising, moderate diet, open air exercise, *change of occupation*, cheerful company, &c., — it will pass through successive stages progressively, as, *altered* mind; *alienated* mind; *blunted* mind; and lastly, *mindlessness*, with helplessness, — a mere wreck, an incurable case, a most deplorable object.

I believe this to be a true brain palsy from loss of brain, nerve, and muscle power, and calls for electric treatments. A powerful impression made by faradaization, directed over the back at one sitting; to the legs at another; and to the arms at another; and over the abdomen and thorax at another sitting, for reflex influence, (where the primary current is not at hand,) and for electro-muscular exercise, helps to rally these patients wonderfully, when we can bring them under its influence early enough. Such cases so completely recover, that it is usually denied by themselves and others that they ever had a touch of it; but if they come later for treatment, we fail to arrest the progress of the disease, and can do them no good whatever.

*Erethism*, from *erethismus*, a Latin word, which means irritation and excitation, is a term, doubtless, that most nearly conveys a right idea of quite a large class of nervous affections, treated of, according to their *stage*, either under the type of hyperæsthesia, or that of anæsthesia. I would consider, here, those cases that are produced by a damaged condition of the nervous system; as by the abusive use of mercury, tobacco, intoxicating

drinks, or the habitual use of opium; or from lead, arsenic, or other slow or protracted poison taken minutely; as also most of those cases of hypochondriasis, and some nondescript nervous affections *from protracted mental labor*, or sensual abuses. These are all characterized by a great depression of strength and spirits; anxiety about the heart and stomach; *actual feebleness of the heart's action*, and sometimes irregular actions; gloomy forebodings, sighing, crying, tremors, quick feeble pulse, often a sense of chilliness, and of nausea; sometimes vomiting, but almost always a clean, or whitish-pale tongue, with the general functions, apparently, but little disturbed; although, it is true, a sudden exertion, if great, is liable to prove speedily fatal. The predominant impression on the mind of these patients, is, that they have incurable disease of the brain, or of the heart, or an approaching palsy.

Aside from their own impressions and sensations, we actually find, as the most marked condition, dilatation of the pupils, *a feeble heart action*, a tired sensation, with generally diminished powers. The ganglionic centres, especially *the solar plexus, appears to be the seat of the affection*, which drags into the vortex the mind and the will, as well as the body. In this class are cases that may be termed *erethismus mercurialis*. Such cases are now and then met with, and are characterized by very great depression of strength; tremors of head and limbs; small, quick fluttering, or sometimes intermitting pulse; anxiety about the præcordia; frequent sighing and nausea; occasional vomiting; pale and shrunken countenance; sensations of chill, or coldness, with goose-flesh. But the tongue is usually clean, or seldom furred, nor is the mind affected. While in this state, any slight impression brings on the *agitans*, or trembling, and any violent impression, or any sudden exertion, may prove speedily fatal. Erethism, produced by whatever cause, is then, in the first degree, excitant; in the last degree, a depressant. General stupor, muscular stupor, or, in other words, numbness, attended with a prickling sensation, or formicans — a sensation like that of crawling insects on the skin, or like that of a limb when it is said to be asleep — usually felt in the lower extremities first, and then extending to other parts of the body, and perhaps

attended with diminished or impeded voluntary motions, but without coma, is but *ultimate erethism*. In these latter cases, when we cannot trace it to mercury, or other poison, we must suspect ganglionic *dyspepsia*, and be on the lookout for it.

In all cases of ultimate erethism, we shall find diminished nervous energy, and impeded circulation. Therefore, prescribe digitalis with tinct. ferri or conium, and alternate with quinine, or tincture of bark combined with tincture nux vomica, in equal parts. At the same time apply electricity over the vital organs, smartly, through large sponge electrodes, by circle treatments. Moderate exercise, plain good diet, and occupation of mind. They will slowly but surely recover.

The following class of cases, doubtless, belong to this category of ganglionic affections.

*Hypochondria, attended with feeble heart action, nervous dyspepsia, and with spells of agony.* Several individuals, all of them males, with these peculiar characteristics, have come under my own observation and care. One case, a Mr. D., sent me by Dr. H. J. Bigelow; another, Mr. H., by Dr. O. Saunders; another, Mr. J., sent to me by Dr. D. H. Storer; and several others. This class of patients are usually in the middle or prime of life; and the majority are *apparently* in full habit, and in otherwise seeming health. All those cases we have seen were comfortably situated in money matters, but had evidently done hard service, in the way of by-gone mental taxation, or protracted anxiety. The appetite is good, and, as we have said, the embonpoint is admirable: one casually seeing them would naturally suppose them to be in perfect health. They are usually supposed to be "*nervous*," hypoish, or lazy, or crazy; while at the same time their illness, or, I may say, their peculiar misery and sufferings, are as real and tangible to them, and evidently far more unendurable, than those experienced by persons with fatal fever, or many a serious sickness.

Total prostration of *nervous energy* is the most characteristic feature we get from all their story. The dethronement of *will-power* is as evident as in cases of hysteria in the female; and I believe it to be its counterpart. The pains and sufferings, whether real or imaginary, they evidently *cannot bear*, and there is no

disposition, courage, or pluck for business. They cannot even *try* to do any thing; and some of them show total indifference, or even disgust, for their business; while others worry perpetually, in business hours and out, day and night, about their supposed poverty, but can put forth no sort of effort to avert the impending ruin. Weeping is uncontrollable. They are *inclined* to tell every body that comes near them, strangers or not, all of their malady, and seek as earnestly to know if there was ever any one just like them.

These persons complain, most of all, of great weakness; of a disagreeable feeling in the top of the head, or more in the back part of the head and neck, together with sinking turns, *as if the heart stopped*, or might stop; and with morbid forebodings of impending death. An irresistible melancholy seizes the mind, *by times*, which they find it quite impossible to shake off, by any and every effort of the will they are capable of making. And another feature is, that they show these symptoms more in the latter part of the day, and evening, at which time there culminates an aggravation of miseries, that by them is quite indescribable and intolerable.

In all these cases of erethism, the heart's action, and the pulse, are found to be feeble; the stomach and the duodenum are much of the time filled with flatus. There is an insufficient and incomplete distribution of the blood, due to an enfeebled state of the ventricles of the heart, from want of nervous energy; and ultimately, if the person lives on, being only temporarily relieved by alkalies and stimulants, without a radical remedy, this will increase until fatal, through incipient fatty degeneration of the heart. The brain is also involved, being very poorly nourished, and there the *will-power* suffers most.

*Treatment.*—The great modifier of the solar plexus, we know, is electricity, *applied directly over the vital organs;* and this is the first thing to be done, and to be repeated from time to time. About noon is the best time of the day for this seance, in these cases. The food must be good, but plain; avoiding potatoes, and the like, at every meal; for dinner, food consisting in part of *broiled* or roast beef or lamb, with a tea-spoonful of brandy; no soup, and but little fluid; but one cup of moderate

tea, or coffee. Horse or foot exercise to be only in a walk; or a light gymnastic practice, if you can get him to persevere in it; cheerful company, much in the air and sunshine; early rising and early retiring; *and no mention whatever of his or any other malady.* Quinine one grain, sulph. ferri half grain, strychnine one fiftieth of a grain in pill, once a day and long pursued; a table-spoonful of brandy, or half a glass of wine at dinner.

Thus we may cure every such case, if taken in season, provided this plan is not departed from. When such cases are neglected, or not understood, they have a tendency to run into confirmed hypochondriasis, with a fatty degeneration and soft hypertrophy of the heart. From the extreme feebleness of the heart in late cases, *emboli* result, threatening life by apoplexy; or by local mortification, and sudden death.

*Embolism* is a cause of very various and serious palsy; but are the members of the medical profession, generally, sufficiently on the lookout for it? The local obstruction of circulation, either in the out-flowing arteries and arterial capillaries, or in the return-flow current through the veins and venous capillaries, is too often out of mind while conning obscure cases of palsy. When the mind does revert to the circulation, is it not too often interpreted — as somebody has said — a sluggish liver, or simply a diminished nervous action, or a weakness in the heart itself? But we are not now alluding, on the other hand, to that state of things where we find the blood coagulations producing a general obstruction of all the vessels of an entire section, thus filling all the arteries with a homogeneous *thrombus*, which results in the absolute stasis of the entire capillary circulation of the affected region, (local mortification,) and which may become general; nor do we refer to those coagula which are sometimes found in the cavity of inflamed vessels, and are only the products of local stasis, and sometimes caused by a roughness of the inner surface of the vessel by alteration of structure, the result of altered nutrition, and may be more or less general — for neither of these latter forms of impeded circulation is of an embolic nature.

What we here refer to, are, those coagula which exist without a simultaneous lesion of the arterial wall, or adjoining capillary

circulation; are never formed on the spot, but have been separated from a distant part in the circulation, and have been carried by the current of blood as far as they can go. This is the genuine form of a paralyzing embolus. It is found, always, in places where a large arterial trunk, by giving off branches, suddenly becomes smaller in caliber; and the vessels beyond it are, in general, empty, or nearly so, to the periphery.

Since the researches of Virchow we have had, from various sources, examples of hemiplegia caused by embolic obstructions in some cerebral artery. Dr. Barrows, in the English *Medical Times* of February, 1853, shows that, notwithstanding the hyperæmia of the softened portion of the brain, distinctly pointed out by himself, this softening, in primary cases, is produced by the cutting off of the supply of blood by anæmia. Dr. Eisenmann appended some remarks respecting the hyperæmia constantly found in *red softening* with arterial obstruction. Hyperæmia and stasis, he says, are developed here, as in other organs, when collateral branches find access to the channel of the obstructed artery; but where this does not take place, collapse ensues. Softening of the brain after emboli, is, therefore, *not* caused, like senile gangrene, by want of blood, but is caused by serous effusion, in consequence of hyperæmia.

Other writers — as Dr. Traube, in the *Deutsche Klinik*, 1853, No. 44 — contend that this softening depends upon diminished nutrition and arrested metamorphosis of tissue; consequently, on an absolute stasis of the current of blood, and not on hyperæmia through the collateral vessels; and in this view, I believe, Dr. Bunce Jones concurs. While Dr. Cohn reports a case where softening of the brain was caused by a plugging of the *arteria fossæ Sylvii*, Dr. Bierck reports a case in which complete hemiplegia depended upon a clogging of the left ventricle artery and of the artery of Sylvius. In this case there was heart disease.

Moreover, it is now well known, — and not until lately was it known, — that certain severe forms of intermittents, as the congestive intermittent fever of the south and west portions of our country, may give rise, in the cases that survive the attack, to a

considerable accumulation of thick *pigment in the blood*, which, by obstructing series of vessels of various sizes, occasions numerous anatomical and functional disturbances; as more or less paraplegia, anæmia, anæsthesia, and atrophy. Developed in the spleen, as is now supposed, and conveyed to the *vena porta*, it gradually increases in size until it gets lodged in the bifurcation of the vessels, in the different bony passages along the spinal canal, and in other intricate parts. Hence this sequel of these fevers. Recent researches for the origin of these embolic bodies, which, like floating rock-moss or sea-weed, are liable to become clogged by a current, have made it clear that they may be formed either in the arteries or veins, in the portal, the lymphatic, or the chylous system.

Emboli are found to occur, then, in the arteries of the brain, of the medulla spinalis, of the eye, the heart, the liver, the stomach, the spleen, the kidneys, in the extremities, and in the *vena porta*. They can give rise to congestions, syncope, asphyxia; to softening and gangrene; to rigors, fever, neuralgia, and convulsions.

*Treatment.* — Where this state is suspected or known, the treatment would seem to be, to speedily give *tone* to the tissues, to increase the nerve power of the heart and arteries — the vaso-motor power and action. For the method of using electricity here, see page 468, *Rule* 13. In individual cases the mode of treatment must vary from boldness to extreme caution; for the plethoric and robust we have the antiphlogistics, as antimony and veratrum; for the anæmic we must use brandy, iron, quinine, and strychnine in very small doses. But we must bear in mind that the same embolic softening of brain or cord may, in a day or two, more or less increase in *danger*, as manifested by peripheral irritation, or inflammation, and thus seems to call for prompt treatment. If neglected but a few hours, perhaps, complete paralysis may follow in its track.

*Sudden death* may occur from heart-clots, or *thrombi;* which has sometimes been ascribed to brain or heart disease; while the coagulated blood found, was supposed to be *post-mortem* clots. But recently Dr. Meigs, of Philadelphia, has shown, by a variety of cases, that this is an ante-mortem formation. Three of

these were diphtheritic cases; and others were accidental formation of heart-clots in parturient women, as a result of syncopal conditions, occurring in subjects who had recently lost blood, thus increasing the coagulability of what blood remained in the system during the slow movements of the heart while the fainting fit lasted. That is, any patient that faints, if the blood, from any cause, is too coagulable, may actually die; not directly from the fainting, but from the coagulation of the altered blood that is in the heart and great blood-vessels at the time the accident of fainting takes place, if it should be protracted.

The importance of investigating obscure cases, rather than too readily give them up, is illustrated by the following: —

Mr. P., of Roxbury, a slender and rather delicately-built man, aged thirty-four, unmarried, manufacturer, spends much of his time in his counting room; is dyspeptic, thin in flesh, and complains of numbness in his heels and hands; a crawling sensation in the limbs and over the head; fatigues easily, and rests poorly nights. His appetite was good, but his stomach and bowels felt uncomfortable and heavy the most of the time, with much weakness in the back; somewhat constipated, and the urine cloudy. After consulting many physicians, and taking various prescriptions, he came for electric treatment. By means of various sittings I could not discover any organic disease in head or spine, in thorax or abdomen; but the patient did not improve in the least; was rather losing ground, as he had done for a long time before. I reëxamined, and ransacked, and had his urine examined once more; its variable milkiness was now found to be caused by *fat*. This was a new fact.

Here was a peculiarly morbid state of the system, eliminating fatty matter in the urine, after its ingestion in the ordinary way with meals, showing *faulty pancreatic juice*, probably from a morbid state of the solar plexus; for there was no tumor, no pain, no evidence of local disease. I prescribed the nitro-muriatic solution, which he had at some time previously taken, and now began *to thoroughly electrify the umbilical region* every other day, with a large current, and through large sponge electrodes; aiding by kneading and deep-shampooing. He commenced to improve at once; and after some eight or ten weeks'

time he felt quite well. It is now six years since, and he has been, and is, in fair health for a slender man, doing a large business. He has not had a sick day since the electric treatments.

The case of H. C., aged forty-eight, with *hemiplegia* of three years' duration, actively and successfully treated by electricity, and reported by Dr. Harry Lobb, of London, is so instructive by illustrating *the action of the inverse primary current, in affections of the great nerve-centres,* as first practised by Professor Remak, of Berlin, that it is here given. Observe carefully the features of this case.

"The one-sided paralysis came on, in this patient, gradually, with a series of fits, not of a very severe nature, and only partial loss of unconsciousness; his memory is a good deal affected, and his speech is a little thick;" he has what he calls his attacks even now, occasionally. He describes them as a giddy feeling, lasting but a short time, but incapacitating him from any voluntary motion, or use of the *will*, during the time. I have never seen him in one. On applying at the hospital last July for treatment, there was stiffness in the leg, with some little ability of walking. The right arm was entirely powerless, with contraction of the pectoralis, biceps, and flexors of the hand, so that the arm could not be straightened, nor the hand opened, even by using great force; he had no power in it at all.

"*The treatment* commenced with the *galvanic direct continuous current* applied to the paralyzed and contracted muscles. At the time, I was not practically aware of the power of the *inverse primary* current for removing the contraction of muscles when it is the result of disease (functional derangement?) within the brain. The treatment with the direct current, as commenced with, was persevered in for six months, with some benefit sufficient to satisfy the patient that he was deriving advantage, but not of a very marked nature. During this time I had learned the virtue of *the inverse primary current* in overcoming certain central-caused muscular contractions. Consequently, in February, I applied the *Pulvermacher chain, inverse,* (continuous primary current,) i. e., reversed the poles, by placing the wet-sponge electrode, attached to the positive pole, upon the bellies of the

shortened muscles, while the moist sponge of the *negative* electrode was placed on the left temple. In twenty minutes the arm became perfectly flaccid; the previously contracted or shortened muscles were quite soft, and the hand could now be opened without any resistance. He had as yet no voluntary power in the arm to extend it, or to open the hand. On each visit there was less of the crippling and deforming contraction; and now, immediately after being electrified, he can stretch out the arm fully, and can open the hand.

"I look upon the use of the *inverse continuous primary current* as giving to therapeutics a vast power for a class of cases hitherto unthought of; and likely to be almost as useful as the *direct* continuous primary current is for other classes of cases. To the physiologist these facts cannot but be of the greatest interest. *I fully believe that the wonderful difference in the effect of the* direct *and of the* inverse *galvanic current has not been sufficiently recognized by authors.*"

Such is the recent experience of a very accomplished and accredited medical gentleman, who has an extensive clinical field in both hospital and private practice. The action and effect of about one hundred links of a Pulvermacher's chain are nearly equal to twenty-five cups of a Daniell's battery.

We may be prepared to find true hemiplegia far more frequently on the left than on the right side; and it is limited exactly to the median line. The attacks are various — sometimes gradually beginning in the fingers or toes, the legs or arms, and then extending successively over that side. When there is spastic rigidity of some of the flexor muscles, or cramps, or convulsions, they are to be viewed as grave attendants of this sad affection; and usually in such a case there is to be suspected some inflammatory softening of a portion of the brain, which is to be considered still more probable *if there is much pain in the paralyzed limbs, or contracted muscles.* In this state of things, postponement of the electric treatment is certainly prudent; but if already of long standing, and nothing is to be gained probably by delay, nor yet from other medication, then let the trials be made, if at all, with the greatest caution and gentleness,

as regards strength of current, as well as length of *seance*, and adroit manipulations, — closely watching the effects.

Dr. Todd says, we shall very seldom find a hemiplegia produced by disease of the upper part of the spinal cord; but when this is the case, the paralysis is usually local, affecting, perhaps, the right shoulder and arm *at first*, but then soon becoming more general. The author has recently had under treatment two cases that thus *originated*, and had resulted in a sub-luxation of the shoulder joint from the paralysis of the posterior portion of the *deltoid* and other shoulder muscles, while the *biceps* and *coraco-brachialis*, remaining intact, drew the head of the bone from the glenoid cavity. (See *Sub-Luxations.*)

We must also be prepared to see hopeless cases of hemiplegia, as the *congenital*, and not arising from recent lesion, but rather depending upon defective development and growth in some portions of the cord or brain, causing various complications of hemiplegia, as choreic, or idiotic, or stunted growth of limb or body, or sometimes all of these together with contractions of some of the flexors, and showing agitans. No sane man would think of benefiting such by subjecting them to any active treatment with electricity.

The following condensed propositions are laid down by Dr. Gull, of Guy's Hospital, viz.: If there be disorganization of the hemisphere, whether affecting the anterior or posterior lobe of the brain, implicating the *optic thalamus*, or *corpus striatum*, singly or equally, and if the lesion be of such an extent as to produce a hemiplegia, "then there will be a greater affection of the upper than of the lower extremity, and a greater loss of motion than of sensation." If the lesion has been sudden, and both the upper and lower extremities are completely paralyzed, the leg will begin to improve before the arm, and the muscles nearest the trunk will regain their power first; that is, for example, the deltoid and flexor of the elbow, will recover before the muscles which move the fingers. As regards sensation, it is sometimes abolished, (as the intelligence is also impaired or lost for a few days following the attack, if the lesion has been *sudden*,) but is soon recovered from, like the recovery of muscular power, *first in parts nearest the trunk;* but this, *first in the leg.*

According to Dr. Burdach, out of some thirty-eight cases of cerebral lesion of one side, the muscles of the face were paralyzed in twenty-eight *on the opposite side* from the lesion, while ten were on the same side. The seventh nerve, then, when involved in paralysis, *is more commonly crossed*, like that of the body; yet the exceptions are frequent, and are to be borne in mind. He also affirms that a lesion of the third nerve, producing paralysis of the eyelid, was, in six cases, on the same side with the lesion of the brain, in five on the opposite; paralysis in the muscles of the eyeball in eight cases on the same side, in four on the opposite; and paralysis of the iris in five cases on the same side, and in five on the opposite.

In the British and Foreign Medico-Chirurgical Review of January, 1850, Dr. Gull further states the facts which have fallen under his own observation, as regards paralysis of the third nerve, as follows: 1. Pupil largest on the same side of the disease in the brain; vision being lost. 2. Eyes turned *from* the paralyzed side. 3. *Ptosis* on the side opposite to the paralysis of the extremities and the face. 4. Though no obvious affection of the *iris* or *recti* may exist, yet a patient may turn his eyes most readily *from* the affected side, and open the eye the widest on the side of the paralysis. Hence he concludes, that when the third nerve is implicated in ordinary hemiplegia, and is affected either slightly or considerably, *it is the nerve of the same side with the lesion that suffers;* whilst the paralysis of the facial nerve, and still more uniformly the paralysis of the spinal nerves, is *crossed.* These latter propositions, so far as they relate to the portio dura, we should say, however, are still doubted, by many learned pathologists.

### *Electro-Muscular Diagnosis of Brain Palsy.*

*Electro-muscular explorations*, when carefully and understandingly performed, are very important *Diagnostic*, as well as *Prognostic* means now at the hand of physicians, to be employed in cases of paralysis that present either for treatment or simply to learn the prospects of a treatment. The loss of electro-muscular contractibility (when properly tested) enables

us, first, to distinguish those paralyses that are due to an invisible or otherwise undiscoverable cause, — as, for instance, where there is a local, idiopathic, or traumatic lesion of the nerves, — from those cases which are still depending upon a true cerebral origin and cause; for in this latter, the susceptibility of the palsied muscles to contract, when under the influence of Faradaic currents, remains *more or less intact;* while in the former, i. e., where the paralysis is purely from a local or traumatic lesion, this phenomenon is always utterly wanting.

*Paralysis*, of all degrees, when viewed generally with reference to the condition of the muscles and their nerves, may be classified by us according to the mode in which the part paralyzed is influenced by a given electric current. Thus we may form two classes of this affection. The first are those in which the muscle or muscles *do* respond readily to this stimulus, showing contraction promptly wherever it is applied; the electro-muscular contractibility remaining, as in health, or is increased. The second are those in which the muscles, under the influence of the electric current, do *not* contract, or contract but slightly; the electro-muscular contractibility is impaired or lost.

To the first class belong those cases of paralysis that are purely *cerebral*, whether produced by apoplexy, (hemorrhage,) inflammation, softening, tumors, or other lesion; as also those paralyses called hysterical, and some of those denominated rheumatic; besides, in this class must be placed those cases of palsy attended with fatty degeneration of the muscles; for so long as any of the muscle fibres remain, they exhibit electro-muscular response. In this class, therefore, will be found a wide variety of electro-muscular response; for in most it will be intact; in others, increased; in some, diminished.

To the second class belong those cases of spinal paralysis, caused by lesions, traumatic or otherwise, of the spinal cord; or else of the nerve-trunks; and including, also, those large classes of *old* rheumatic palsy, and lead palsy. In all this class the electro-muscular response is diminished or lost. Generally, according to the degree of loss of electro-contractibility, will be the degree of electro-sensibility.

To test, or ascertain the *relative condition* of the two sides of

such a patient, be particular in making the application of electricity on the two sides alike. For instance, place the positive sponge electrode on the middle of the deltoid muscle, and with half battery power, or less, apply the negative sponge on the middle of the group of extensor muscles of the fore-arm, and notice the effect — whether any, or how great — the muscle movements are under a given strength of current. The same may be done with the sciatic nerve and thigh muscles, or the peroneal nerve and leg muscles. Then repeat this on the well side, in precisely similar places, with the same strength of battery power, same current direction, and with the same pressure or manipulation of the electrodes; then back and forth for several times, until a fair comparison is well made out. If the extensors do not thus readily respond, employ more current; or try the axillary plexus, or the median nerve, with the positive electrode, and the flexor muscles of arm or fore-arm with the negative. But if such a case presents a *rigidity* of muscles, these testings can do no good, and may possibly do harm if continued or repeated for any considerable time.

Dr. Radcliffe considers that the "*late* rigidity is the anticipation in the part of rigor mortis, — *rigor mortis in vitâ*, — and nothing more or less." He employs faradaic electricity in such paralysis, by *localized faradaization*, as severe "shocks of the coil machine, until the operation is followed by a sufficient degree of vascular reaction; with the intention of affecting the vaso-motor nerves of the *centres* involved."

*Precautions.* — The immediate or early employment of electricity in this accident, I contend, *should not* be the rule. Let us see why. The primary cause of the attack of hemiplegia may, for all practical purposes, be classified: —

1. *From Destruction* and giving way of nerve-fibres at the base of brain. — In this class, where we have reason to think, from the previous history, that there is an old morbid or diseased condition, leading on to softening, white or red, of the cerebral substance, we should not employ blood-letting early or late; nor even the early use of faradaic currents, except as test, and perhaps for faradaizing the paralyzed muscles below the knee and elbow, with a down-running current. This, in some cases,

does evidently help to restore from so much of the paralysis as is produced by shock.

2. *From Compression of Nerve-fibres*, as *by a solid* at base of brain. — Were it possible to clearly diagnose hard pressure, what service could we render by bringing electricity to bear early, after such an attack? Here mercury, iodide of potassium, or the proto-iodide of mercury, is rather indicated.

3. *From Compression by a Fluid.* — Nor in this more frequent class of cases would we reasonably expect benefit from the *early* resort to electricity as an active treatment; rather we might expect harm. The extravasated blood is in all probability still fluid, for we must be reminded that the blood does not thus coagulate, as it does when let out to the atmosphere; but can, and probably does, in these cases, remain fluid for many days or weeks after the accident.

*Prognosis.* — In all cases of paralysis, the cause of the palsy very materially indicates its probable termination; the condition and situation of the patient also aid to this opinion. Generally speaking, palsies produced by the various poisons, which being eradicated, usually recover; as do those from cachexia, syphilis, hysteria, and some nerve injuries, wounds, and diseases. Old rheumatic palsy is prone to be obstinate; as is also palsy from nervous exhaustion, from excesses; but palsy from a cerebral lesion yields the most grave and unfavorable prognosis; yet even here we may entertain hope as long as reflex movements can be excited in the palsied limbs. But after all irritability and inflammation in the nerves and nerve centres have subsided, — when the organic injury has been repaired, if ever so feebly, and the continuance of the paralysis is owing only to debility of the nerves and their centres, and defective nutrition in all the parts concerned, as also from the habit of inertia, — the faradaic or galvanic electric current, rightly applied, exerts a curative influence that no other remedy can reach.

Usually, in cases of cerebral paralysis from apoplexy, in about four to six months after the accident, more or less, according to the gravity of the case, and the skill of the operator in making prudent first sittings, where the palsy persists *without* any contraction of the muscles of arm or hand, leg or foot, — treatment

may begin; and a cure, by the aid of electricity, and other suitable aids, may be expected with considerable certainty. But where there is persistent contraction of fingers, hand, or foot, wrist, elbow, or knee, it is not suitable for electric treatment; as this condition indicates a persistence of cerebral inflammation, irritation, or softening, which has not ceased, nor will be likely to do so. Little hope of recovery need be indulged where this condition so long persists.

The mere *stiffening* of a muscle, in these cases, arising from its shortening by long fixed position, or palsy of extensors, must not be confounded with the above *tonic spasm* or *rigidity*. Also, if there be only temporary, irregular, or involuntary contractions, the prognosis is not so unfavorable. It is a good rule, in treating cerebral palsy with electricity, to commence cautiously with a moderate current, by frequent intermittences, and a short seance of not more than five minutes altogether, and not repeated oftener than every other day, or twice a week, until the true state of the brain has been sufficiently tested.

And further, we find that the *gravity* of the given case of paralysis is in direct ratio to the loss of the electro-muscular *susceptibility* and *contractibility* of the muscles affected. But if this *muscular* "*sensibility*" is preserved, *or even partially so*, and that even where the electro-muscular *contraction* has become extinct, we learn that this great gravity is in some degree diminished, particularly if the neighboring muscles also show a *normal response* by electro-muscular contraction. This region integrity, where the case is not of too long standing, so that the sick muscle has not already passed by degeneration into a fatty state, is always a very favorable sign, at least as possible, or probable, that these muscles, under a judicious use of Galvanic or Faradaic currents, will rapidly recover. Moreover, we can now classify these cases even closer than this; but let us first notice the opinions of distinguished men upon this subject.

We observe that systematic writers arrange all those affections of the human organism that are designated as palsies, or paralyses, (which is the same thing,) under three general divisions, viz., 1. *Paralysis from brain origin.* 2. *Paralysis from spine origin.* 3. *Paralysis traumatic or reflex.* And under this

last head are arranged all those cases arising from primary local effects upon the peripheric nerves, as well as those whose primary cause was perhaps from a brain lesion, (which is now restored,) and the remaining paralysis is only local.

The opinion of Dr. Duchenne upon this most grave question must certainly be considered. It has been declared by him, as also by Marshall Hall, Becquerel, and other physicians, that electro-muscular contractibility remains, or is exalted, in all those cases where the origin and cause are in the brain. That is, if Faradaic currents are localized in the affected muscles, or where one pole is placed on the muscle and the other is over its nerve trunk, there can be produced visible contractions in the palsied muscle itself, which, however, will fall back into its helplessness as soon as this influence is withdrawn. Dr. Duchenne is of the opinion that all such cases as arise either from a lesion of the brain, or of the spinal marrow, *are by no means "necessarily" suitable cases to receive electrical treatments during the earlier stages*, —certainly not until after some six or eight months after the attack. But where the red or white softening, or the apoplectic clot, has not caused the person to sink under the immediate shock, but, on the other hand, the person has rallied, although slowly, and the clot has undergone resorption, and the hemorrhagic focus has cicatrized, or the softening has been restored, (either of which being manifested by the general appearance, history, and electro-muscular test,) no doubt in such favorable cases, judicious electrical treatments may be resorted to, not only with safety, but also with the greatest benefit. In some of the more favorable cases, we shall often find nature restoring in part, at least, some of the voluntary muscle movement, and this is another favorable omen. Dr. Duchenne declares, however, that in recent cases of paralysis, so long as the work of cicatrization of the damaged brain is not completely terminated, he finds the application of induction currents, (in the way he employs them,) as treatments for restoring motion and the power of the will, is not only useless, but may prove very hurtful. In fact, it has been frequently observed that from the too early resort to this active agent, and that perhaps in no kind of order, new cerebral hemorrhages are more apt to

follow. He in another place says, however, that nothing is more variable than the duration of the time that is absolutely necessary to bring about cicatrization in each individual case; yet after a delay of some half year, more or less, we may employ Faradaization for those paralyzed muscles, whose electro-muscular contractility *has only been diminished by the prolonged inaction*, and severance from the influence and coöperation of the will.

Duchenne shows that for those muscles in which the prompt electro-muscular contractility has remained quite intact, such muscles gain nothing from electrical treatments for their *voluntary* contractility, *if this power is lost* in whole, or in part even, as this loss of *voluntary* action, while there is prompt electro-muscular response, is not from the incapacity of the muscle to contract, as is thus proved, but it is from a want of functional continuity of communication with the organs of volition at the base of the brain. But in the former cases, where the paralysis seems to be mainly, if not entirely, *localized* in the muscles, and this diminished action is from inaction, then the employment of Faradaization of those muscles becomes highly useful, and often completely successful.

Even such results will not be happy, however obtained, except so long as the hemorrhagic focus, or other lesion, is nothing more than a healthy cicatrix; for if, after the resorption of the effusion, whatever that may be, if there remains a persistent clot, or debris of a clot, or a cyst of any size, or if the brain has suffered any considerable loss of substance, then even, also shall we realize a failure of the best electrical treatment.

On the whole, then, we infer from his reasoning, which is based, as we should bear in mind, on the earlier but most extensive experience in systematic electro-medical practice, that it is very difficult to determine in any exact manner the condition or degree of the lesion in the brain; but that some six months after the malady first showed itself, the paralysis being no longer *caused*, or, in other words, *sustained*, by the central lesion, and that under the above circumstances, and where there is no sort of rigidity which characterizes all such cases, it can then be

safely treated by Faradaic currents, and that many of such will be greatly benefited, or completely restored. In proof of this he gives a variety of striking examples.

As to the distinctive characteristics of the two great classes of cerebral and spinal paralysis, as manifested by the electric test, we find that M. Becquerel has studied them particularly. He comes to the conclusion, that there must necessarily be distinctions for particular cases. The degree or intensity of the susceptibility of a case to electro-muscular contractility is found to be about in proportion to the conservation of the power and ability of voluntary movements; i. e., in the muscles affected. So that this susceptibility disappears in an absolute manner, only, where the paralysis is complete, and where, at the same time, the voluntary movements are entirely abolished.

For all of this kind of cases, Dr. Becquerel advises the more simple kinds of treatments by Faradaic currents, and especially directs that each *seance* be short. But he does not so appear to dread the effects of reflex action from this procedure, but rather embraces the nerves in the current with this expectation.

The peculiar views of Dr. Marshall Hall, so important on this point, may be profitably rehearsed here. He gives as the result of his conclusions, that all kinds of muscular paralysis may be arranged, by the electro-muscular test, into two great classes — first, the Cerebral; second, the Spinal: this latter includes all local, peripheral, and traumatic cases. Thus he speaks: —

"I designate that paralysis as *cerebral*, in which, by whatever means or disease, the influence of the *brain* is severed; and I designate that form of paralysis *spinal*, in which, from whatever cause, the influence of the spinal *marrow* is *severed*. It is unnecessary to state, that in the latter case the influence of the cerebrum is removed, as well as that of the spinal marrow.

"Before I proceed, I must take the opportunity of briefly alluding to the *functions* observed in the muscular system; for it is these that are variously affected in paralysis. The first function of the muscular system which I shall mention is *voluntary motion*, the *effect of volition:* the second function, or rather affection, of the muscular system, is the *effect of emotion;* the third is *reflex action;* the fourth is *the tone* of the muscular system;

the fifth is the *irritability* of the muscular fibre. *All* these are wonderfully involved in every muscular act or action, though *one* may be principally so, and the affection of *each* becomes to the physiologist the source of diagnosis in cases of paralysis; for I may take this opportunity of stating, that *in the diseases of the nervous system, the electro-physiology is* the *diagnosis* of the case."

"I will briefly detail the particulars of two cases, which may be taken as *types* of the rest.

"The first was a case of hemiplegia, affecting the *right* side. The muscles of the right arm were paralytic, atrophied, contracted, and rigid. We placed *both* hands in one basin, containing water with a little salt, and the foot in another, and we passed a galvanic current through the limbs so disposed, beginning with the *smallest* force which would produce an obvious movement. Invariably, in many trials, the paralytic arm was moved by the slighter, but the most by a greater force, whatever the direction of the current.

"The second case was that of a little girl, aged two years and a half, in whom the left arm had been suddenly affected with complete paralysis nearly two years before; the head having at the time of the seizure been drawn to one side, and the child being under the influence of dentition. In this case, the paralysis of muscular power was, as I have stated, complete; the arm was atrophied, the muscles flaccid, the hand moving on the wrist, and if held in the dependent position, absolutely uncontrolled by muscular influence. We applied the galvanic *test* as before, using the *mildest* force which would produce an obvious effect. Now, the *unaffected* limb was first and most affected by the galvanism!

"In these two cases we have the marked forms of *cerebral* and *spinal* paralysis respectively; in the first we observe a very marked *tonus*, (contraction;) in the second, abolition of *tonus*, (flaccidity;) in the first, we have *augmented*, in the second, *diminished*, irritability of the ultimate nerves and muscular fibre. In the first, too, there was agitation of the arm on any emotion; in the second, none. I had no satisfactory mode of testing the existence or absence of *reflex* action."

The physiologist, and *now*, I think, the practitioner, also, will see the value of these phenomena to medical *science*, and bring their translation into diagnosis.

Dr. Hall therefore adopted the following rules as *law* in his view: —

"1. That cerebral paralysis *may* exist alone.

"2. That spinal paralysis of course *implies* cerebral paralysis.

"3. That ganglionic paralysis *may exist with or without* muscular spinal paralysis. In case of a transverse division, or disease of the tri-facial nerve, we have ganglionic paralysis; and in a case where the digital nerve was injured, I found the nail ceased to *grow* as formerly. But as spinal paralysis implies cerebral paralysis, it also implies ganglionic paralysis. I have," he says, "at this moment a patient, who, from inflammation of the sciatic nerve from a cold, has lost the power of the limb, and the muscles are absolutely unaffectable by any galvanism — are atrophied, heterotrophied, and, I suppose, are changed into fat. Now, by restoring the healthy condition of the *nerve*, will the morbid change of structure undergo restoration? This is a question. It will require research and experience; but I propose shortly to add to this present brief sketch some more ample details." But he did not live to accomplish it.

Dr. Marshall Hall was thus probably the first to direct the attention of the medical world to the employment of electric currents *as a peculiar means of diagnosis* for and between certain paralytic diseases. But as he assumed, "that the brain is the exhauster of muscular irritability by the acts of its own volitions," he could not deduce or arrive at any rule, because such a position was not tenable. Much has been written since that day upon this subject, by other able men who joined issue, as Copeland, Todd, Perera, Duchenne, and many others.

The most recent, correct, and concise views we find on this question are deduced from the very excellent work on Nervous Diseases by Dr. Todd, of King's College, London. He concludes, that Faradaic currents do serve as a test in the different cases of hemiplegia, to distinguish between an *irritating* and a *depressing* lesion of the brain, but not as a means for distinguish-

ing between cerebral and spinal paralysis. He observed, that *in certain cases*, the paralyzed muscles responded by contractions to the electric excitant very readily, even more so than the sound side, and that in these cases the muscles of the palsied limb always showed more or less degree of rigidity. The degree of this response to the electric stimulus, he concludes to be within certain limits, in proportion to the degree of rigidity; and this latter is in proportion to the extent of the irritating clots, or cysts, *that still exist* within the brain. But in another class of these cases, this stimulus produced very little or no contraction at all; and these were noticed to be those cases usually where the muscles are already more or less wasted. Then in some other of these cases, he found that although the paralysis was almost complete, yet the currents produced equal response in the healthy limbs and palsied limbs of the same patient. These he observed to be cases of true cerebral apoplexy, but occurring in previously healthy individuals who were generally in the prime of life.

He holds, therefore, that *the state of the muscles* has comparatively little to do in the production of these varied phenomena, but that the peculiar effects of the applied artificial currents of induction or galvanism are rather due to the *state of nervous force existing in the paralyzed limbs;* so that, where there is little or no response by contraction, the nervous force in the nerves of that limb is *depressed*, or is so far exhausted. If in other cases the electric stimulus excites contractions of a still more lively character in the palsied muscles, then in the healthy muscles of the sound side, then he concludes that there the nervous force is *exalted*. Then in other some, where there is no perceptible difference from Faradaizing the sound and palsied limbs, the nervous force existing here *is normal;* and all three of these conditions have their significance and interpretation.

When examining cases of supposed *cerebral paralysis*, we usually find that in a portion of the cases, the electro-muscular contractility of the palsied muscles is more or less diminished; that the muscles of such are soft and flaccid; that the polarity of the nerves is diminished. Whereas, in another portion of

these patients, we find the electro-muscular response is unnaturally exalted; and these are the very cases, according to Todd, that present "*rigidities*," and probably have an *exis*- irritative lesion of the brain. Then there is a third por- although fewer in number, where there is no difference in respect to be observed between the healthy limb and the -ara- lytic limb. The following *rule* is thus deduced by the a- of electro-muscular contractility, and all cases of paralyzed mus- cles may be arranged in one of the three following orders of conditions:

First. Where the electro-muscular excitability of the affected muscles, both in regard to their muscular sensibility and contractibility, *is lost, or very nearly so.*

Second. Where the response to electrization is moderately prompt, i. e., much *as the standard in health.*

Third. Where the response of electric contraction is found evidently *increased, even above the healthy standard.*

Now, if we examine these cases, we find in the first class, or those where the electro-contractibility and sensibility are nearly if not *quite lost*, we have, in all probability, a case of *lead palsy*, or of *traumatic paralysis.* But we should bear in mind, however, that some hysterical and rheumatic paralyses, if of *long standing*, do present the very same peculiarities, and that the same may be presented occasionally in diseases of the cerebro-spiral axis; so that other evidence on these points must also aid to the ultimate diagnosis.

Then, if we examine the second class, or those which show a *natural* response to the effects of the current, i. e., both by muscular sensation and contraction, the same as would be produced if the current were applied to the same set of muscles on the sound side, and, *if of long standing*, then we have, in all probability, a case of curable *cerebral paralysis;* but if the case has a history of but recent date, and other evidence also tallies, then it is more likely to be a *hysterical* or *rheumatic* palsy, or a spontaneous paralysis, that has arisen from local cold, or fatigue; but that there is *no lead cause*, nor is the continuity or integrity of the nervous communication from the affected muscles to the spinal cord interrupted, we may rest fully assured.

Then, again, if we examine the class of cases where the response *is exalted above the natural*, when the Faradaic currents are only applied as usual to the palsied muscles, then, in all probability, we have a case of actual brain disease, the result, perhaps, of a long previous apoplexy, the coagulated cyst of which remains as a *persistent irritating lesion*, which is situated within the cranium, and thus sustains the peculiar and true brain paralysis. These cases are not reckoned as suitable or safe for the *electro*-medical treatments.

*Early and Late Rigidity, or Tonic Muscular Contractions from Brain Lesions.* — Here Dr. Todd makes a marked distinction between the "*early rigidity*" that attends some cerebral paralyses, which occurs soon after the attack, and those cases of "*late rigidity*" which are connected also with cerebral paralysis, but occur only after a certain time. In the former, or early rigid contraction, it is shown most usually in the *biceps* muscle of the arm, and in the hamstring muscles of the thigh, but usually greater in the upper limb than in the lower. This varies in amount, in different cases, from a mere increase in plumpness up to a strong contraction that is almost tetanic. The circulation is found, however, as vigorous as in health, and the heat is at about par; but the paralyzed muscles are generally *more responsive* to the electric stimulus than those muscles of the healthy opposite side.

"As in one class of cases of cerebral paralysis, the muscles can take on *early* rigidity, so also in another class of such affections, the muscles may be exempt from this, but ultimately present the state of *late* rigidity. Muscles of such cases, having been flaccid and wasted for a certain length of time, — that is, since the first attack, — then gradually acquire more tension, and become shortened. The *tendency* to assume this rigid state of muscle, under these circumstances, is more marked in the arm than in the leg, and more in the flexors than in the extensors. It is generally supposed to be caused by the gradual shrinking of the cyst, which acts as an irritating foreign body in the brain. In most of these cases the electric treatment should be cautiously resorted to, or not at all. But in some cases of long standing, an electric excitation of those muscles which are

the antagonists of the contracted and rigid muscles may serve to restore the disturbed equilibrium between the groups of muscles. The following case, he says, may serve to illustrate this: —

"Case of *late rigidity:* late muscle contraction — the sequel of a healing brain lesion. A man, named Marsh, had four years ago an apoplectic attack, with consequent paralysis of the right side. The paralyzed muscles afterwards assumed a state of rigidity which has not undergone any considerable change since that time. At present the patient can with some difficulty walk; but the right arm is perfectly useless, as there exists a rigidity of a number of muscles, viz., of the *coraco-brachialis*, whereby the arm is adducted to the side; of the *biceps*, so that the forearm is bent upon the arm. If forcible extension of the forearm is attempted, the *biceps* offers a certain resistance to it, but no pain is experienced during the forcible extension.

"Stiffness is also marked in the *triceps*, although much less than in the *biceps*. It became evident, if complete flexion of the forearm upon the arm is attempted, so as to place the fingers on the *acromion* of the same side, then the extensor muscles of the wrist and of the fingers would be in a state of complete rigidity. If the hand is strongly extended upon the forearm, then the fingers are as firmly pressed against the palm of the hand, so that the patient is obliged to cut his nails very short in order to prevent injury to the skin from them. The tendons project like tight strings beneath the skin. The patient affirms, however, that he experiences no pain when a forcible extension of the wrists and of the fingers is attempted. There is not much wasting in the muscles, and the excitability to the electro-magnetic stimulus is very trifling in the extensor muscles of the forearm, while the flexors of that forearm contract very readily under the influence of a gentle current. The stiffness of the muscles of the lower extremity is much less considerable than those of the arm; it is, however, distinct in the hamstring muscles, and in the flexors of the toes. In walking, the patient drags the paralyzed leg and foot.

"I supposed that in this case the cyst in the brain might have

shrunk to a very small volume, and that the *un*balance in the equilibrium between the different sets of muscles of the upper extremity might no longer be exclusively due to the lesion in the brain, which undoubtedly was the primitive cause of it, but also due in some measure to the long-maintained overweight of the contracted flexors over the paralyzed extensors. I thought that by administering the electric stimulus to the relaxed *extensors*, the equilibrium might be restored. This view was confirmed by the result of the treatments; for after I had Faradaized the extensor muscles of the forearm for some time, the tendons of the flexors, (by reflex action?) which had before projected like tight strings beneath the skin, now became soft and flexible. The patient was able of himself to open his hand and stretch his fingers. But having been some time afterwards exposed to violent cold, and a draught of wind, the flexors again assumed a degree of rigidity. By further treatment, he again improved; but he left the hospital before being completely cured."

We can quote a multitude of facts in support of the accuracy of these propositions, the importance of which is fairly shown in such cases as where the exact cause of the paralysis is not so apparent or decided, as for instance, in traumatic cases, where there is a tumor compressing the nerve trunk, (or other deep-seated cause that produces the paralysis, or pain, or both) — a phenomenon the nature of which is not hid from this test, in the majority of contusions, compressions, or disorganizations. Dr. Duchenne gives a very marked case to illustrate the accuracy and value of this diagnostic power in a patient, where he, from his great experience and confidence in the electric test, was led to attribute the paralysis of the case *to some alteration in the nerve trunk* that led to the affected muscles, notwithstanding the contrary appearances. From a careful examination of the case, by this electric questioning of the nerve and muscle witnesses, there was clearly proved a lesion existing at the level of the emergence of those nerves which constitute the cervical and brachial plexus of the right side. This local lesion, so masked, he found was due to an exostosis of long standing, and which he

succeeded in curing by means of electric currents, and with it the attending paralysis.

From the foregoing facts and deductions, we may be led to suppose that wherever there is a loss of electro-muscular contractility in given muscles, we may fear that those muscles are lost forever; but we must also recollect that the retained electric *sensibility* in a case where there is lost electro-contractibility, which a patient may still now and then exhibit, while the most implicated muscles are subjected to strong induction currents, is, as we have before said, *certain evidence* that the nervous communication with the central organs is not utterly cut off. If, then, the muscles have not degenerated by change of structure into fat, we are after all allowed to hope, but not flatter — to work, but not promise; for now and then we do realize, after patient and persevering treatments of such, the happiest results.

We think we are justified in summing up the following as the order of succession, and amount of *therapeutic phenomena*, such as are manifested in these and similar cases, when under the influence of Galvanic or Faradaic treatments:—

*First*, there is an exaltation of sensibility which may amount to considerable but transitory hyperæsthesia, in the sensitive branches of those nerves touched by the current while reaching the underlying muscle or muscle groups.

*Second*, there is a more or less speedy return of voluntary movements in the muscles that were paralyzed, but in only such as did not entirely lose their susceptibility to the electric stimulus; and next, those that did not entirely lose both their electro-contractibility and muscular sensibility.

*Third*, there is an increased size, solidity, and nutrition of the blighted muscles; and then there is soon shown returning voluntary movements, first in the muscles, and then in the limbs — and that, first nearest the body, and then successively farther out, and last of all the hand or foot. But this latter succession we have not unfrequently seen reversed in the order of events.

Professor Trousseau of Hotel Dieu, in speaking of a case which was a most complete hemiplegia, as regards *movement*, while the general sensibility, the senses, and the intellect were manifestly

preserved *un*impaired, says, "I find myself inclined towards the common opinion of hemorrhage, and yet I feel at times that there are powerful reasons for suspending this judgment — reasons that I derived from the nature of the paralytic accidents themselves. Besides, I remember to have heard M. Recamier teach — and I have since observed it to be so myself — 'that, when there is *dissonance* among the symptoms in this class of grave cases, they are due to *ramollissement;* while, on the other hand, we must conclude that hemorrhage exists where there is a *consonance* in the paralytic phenomena.'" There is force in the distinction laid down by Recamier, and it remains demonstrated, at any rate, that a *sudden* paralysis of a portion of the body *may* be the result of a *ramollissement.*

We may fairly conclude now, that all cases of cerebral paralysis presenting for treatments — say a few months after the causing attack — can be pretty clearly and reliably arranged, by aid of the electro-magnetic test, into *three classes*, two of which are not as yet suitable for this treatment, while the one and larger class of patients, i. e., *where the "electro-muscular contractility" is diminished from the healthy standard*, we may very reasonably hope for a still further restoration, by the aid of electro-therapeutics, or even a complete cure, if at once treated and skilfully managed.

Again, we may conclude that there is no kind of paralysis, where we find *exalted electro-muscular contractility*, except in those cases where the paralysis is maintained by an irritative lesion in the brain; and the greater the irritative brain lesion, the more marked is the electro-responsive phenomenon in the affected muscles, to the given moderate current.

Again, we must not conclude, on the other hand, that all lesions of the brain are necessarily irritative, unless showing for months or more, and to the present time, exalted electro-muscular excitability.

Again, if, on testing, we do find the muscles of a paralytic limb to respond by contractions, on the application of a given *moderate* current, *more promptly and powerfully* than do those same set of muscles on the opposite and sound side, we may fairly conclude *that the paralysis is due to some existing brain*

*disease*, and the lesion, whatever it may be, is of an *irritative character*, and that the case is not ready for this treatment. The following is a case of *hemiplegia resulting from apoplexy, and showing the electro-muscular contractility diminished.*

*First Class.*—Captain G., aged forty-five, has a noble frame and powerful muscles; is of a healthy family, and has led an active life. Last fall, some eight months ago, he had an apoplectic attack, which well nigh destroyed him. He finally rallied, however, after a loss of consciousness for several hours, but very gradually and doubtfully. After some time he was found completely paralyzed on his left side, including both his arm and leg, and also the right side of the tongue and face. He is a gentleman in good circumstances, and had every thing done for him in medical attendance and care, that could be, during the fall and winter. When he was brought to my electrical rooms, this past summer, he showed a recovery of nearly one half of the original paralysis; but the mobility in the tongue, face and leg, is greater than in the arm. This latter was quite helpless; yet he appeared to complain most because he could not walk. He was able to help himself considerably, but in a moderate and trembling way. By the aid of an attendant each side of him, he can get out of the carriage and work his way into the rooms, which are on the ground floor. I cannot learn that he indulges in any excess, and besides, has dismissed the care of all business since the accident. His pulse is sixty-six; his respiration twenty-six. He finds much difficulty in the managing of his hands at the table, and still more in adjusting and buttoning his clothes. His mental faculties are correct, but his wife says he has not his usual quickness of thought or speech; has no pain in his head or limbs, and his speech is becoming improved. The whole left side of the body and limbs is soft, flaccid, and cold, and a little diminished also in size and sensibility, with spots of purple, and numbness, but no appearance of rigidity of any of the paralyzed muscles, as I was able to make passive bending and extension of all the joints. The extensor muscles have suffered the most, as the voluntary aptness and power of extending are less than bending.

I judged such a case suitable for testing by Faradaic currents,

in order to decide on a future course. Accordingly he was placed in the adjustable operating chair for a *test seance*. One electrode was placed upon the nerve *medianus* at the inner border of the biceps on the lower third of the humerus of the affected limb, while the other electrode was swept along, lower down on the muscles of the forearm, first on the extensors and then on the flexors, using but a gentle down-running current, i. e., the negative over the nerve, and the positive upon the muscles; and thus the contact was made and the soft iron magnet was cautiously and but partially introduced into the helix, that the patient might at most but slightly get the stimulus. The current was thus gradually increased; but this in no way affected the contraction of the muscles, and was but slightly felt. The electrodes were then removed from this to the right (sound side) with the current as just employed, when the action upon the muscles was amply manifest to all present.

Here, *the ascertained diminution of electro-muscular contractility of the affected muscles*, taken in connection with the *ensemble* of the patient's history and present state, re-assured me that I was right in judging his a suitable case for electrical treatment. Thus we can bring to our aid the almost exact evidence that there is, or is not any longer, an intra-cranial irritation, and hence that the paralysis no longer *depends* upon the brain lesion, or any brain cause, but is simply in the nerves and muscles, partly from the long inaction, and partly from the loss of intercommunication between these muscles and the seat of volition at the base of the brain.

This case was received in June, for Faradaic and Galvanic treatments, which were followed up every day for a month, and then less often, with only galvanic currents for some two months more, when he felt himself quite restored. He remains to-day perfectly well, but is under careful habits and moderate regimen.

Just here I will add, that from my note book I gather some practical points. He took six sittings each week of fifteen minutes each. Faradaic currents, suddenly alternated, but of moderate strength, were exclusively employed the first two weeks. One electrode used here was the half-inch disk, while the other

was a two-inch sponge. The former was always planted upon some large nerve trunk, while the other traced the edges and surface of the depending affected muscles, but one minute at a time, then a rest of a part of a minute, and then *suddenly changed* in direction for another minute, and so on. One *seance* would be given to the arm, shoulder, and hand; the next, to the loins, leg, and foot. In the beginning of each *seance* there was particular gentleness and care, until the patient became accustomed to it, when the current was gradually increased to a three fourths strength of a good helix machine that was run by two Smee's batteries. After the first fortnight, the last half of each sitting was devoted to the employment of the primary galvanic current, or rather the induction currents were first used for two or three minutes, and then some half dozen minutes were occupied with the galvanic current, interrupted or *reversed* every ten seconds, either on the nerve trunks or over the spine, using from twenty to thirty Daniell's elements. The *seance* is then finished out by using stronger induction currents for extensive surface action, by *labile* movements, and through this means to awaken and produce a general but gentle reflex action. At the end of the first ten days, his friends claimed for him a general improvement. In the course of ten days more, as I find it recorded in my note book, he claims a sensible improvement for himself, as not only more strength, but as to increased warmth and plumpness of the sick limbs, with which his friends seemed both astonished and delighted. After ten days more, his *seance* was arranged so as to occur three times in each week, for the month to come, at the end of which the muscles were evidently much improved by the treatments, — responding more promptly to the electric stimulus, both by sensation and contraction, and there was much more voluntary control and power. The skin was not so dry and cadaverous, while the muscles were larger, more solid, and warm. From this time he took less frequent sittings *to confirm the restoration*, while he was also initiating himself again into his accustomed business.

*Second Class.* — Case of hemiplegia, showing "*exalted*" *electro-muscular excitability of the paralyzed muscles, and thus diagnosticating* "*irritative disease of the brain.*" An Eng-

lish woman, some twenty years of age, first seen by me in the east wing of the Massachusetts General Hospital, at that time under the care of my excellent friend, Dr. H. I. Bowditch. She had the summer before suffered repeated attacks of "fits," which was followed by a hemiplegia of the left side. Since that time she has been subject to epileptic fits, which, however, have become very seldom since her entrance into the hospital. Besides, under the judicious treatment and good care she received while here, her general health improved, and the paralysis of the right lower limb was mostly recovered from, but that of the arm remained complete. There was also rigid contraction of the left fore finger and thumb, and the whole hand remained flexed upon the wrist. She suffered much from pain in that shoulder and arm, and was sleepless and irritable, yet manifested the greatest disinclination to move about the room; and still much less was she inclined to walk out, as she was somewhat able to do. It was requested that the case should be tested by electricity: accordingly the ordinary electro-magnetic machine was provided, and a medium current was applied to the *median* nerve and the depending muscles of the paralyzed arm. The results, at first, were doubtful, and for this reason the case is introduced here. Her general aspect was certainly promising, and, strange to say, I could not learn that there ever had been any *ptosis* of the upper eyelid, nor paralysis of the face; yet I felt doubtful as to the character or state of this case, as did also the physicians of the hospital. In this state of things, although she had slight epileptic attacks from time to time, it was thought advisable to repeat the electric test or treatment every few days, in a cautious way, until there should be improvement, or manifested contra-indications for its employment. In the course of a few days it was discovered that on placing one (the positive) electrode over the nerve *medianus* of the palsied arm, at the lower third of the humerus, while the other electrode was applied, say first over the body of the flexor muscles of the forearm, and then moved transversely, but slowly, around the arm to the outer side until this electrode rested over the body of the *extensor communis digitorum* muscle, while a gentle, say one-third current, was circulating in a

downward direction, it was seen that the muscles contracted entirely *too promptly and powerfully for such a current.* Particularly was this phenomenon noticed in the extensors, which now drew out the long-contracted fingers and retained them so, as long as the current thus circulated; but they fell back into their accustomed helpless rigidity as soon as the electrodes were removed. When the electrodes with the same current were transferred to the same muscles of the sound (right) arm of the patient, merely for a comparison, she said the *sensation* was greater; but we saw that the contraction was decidedly less than it produced in the palsied arm. Notwithstanding, the patient declared herself better, and, indeed, she certainly appeared better during these few doubtful treatments; but, as she was already dismissed from the hospital before we commenced the test, she soon left, and was lost sight of. It is highly probable that this fine-looking young woman was actually suffering from a tumor at the base of the brain, and could never be entirely well.

*Third Class.* — Case of hemiplegia, showing nearly *normal electro-muscular excitability of all the muscles.* Georgiana W., aged forty-five, of a somewhat rheumatic constitution, but otherwise always robust and well, until some years ago she had an apoplectic fit, in which she lay somnolent for some hours. She then gradually recovered, but with a total loss of speech, palsy of the left side of the face, and a complete paralysis of the right arm and leg. And thus she remained for some four months, during which time she was despaired of. But to the surprise of friends she soon after that began to recover, and that without any change of medical treatment; indeed, without any active treatment at all. Her improvement was so rapid that in three or four months more she was, to a degree, on her feet again; her speech had partially returned, and the paralysis of the face was apparently quite restored. From this, however, until she was presented at my rooms for electric treatments, (which was several months,) there had been no mentionable change for the better, but in some respects, a losing.

Her speech I found to be remarkably slow, and quite imperfect. When she attempted to speak, the tongue was inclined

to one side, and the deep fibres of the *orbicularis-oris*, were constricted. Her gait was unsteady, the arm mostly helpless, and her head felt to her, she said, as if swimming and very heavy. The appearance of those muscles that remained still affected were, evidently, in a remarkably good condition. True, they were rather delicate to the touch, but they were plump and warm.

Here I at once concluded, that we had another unsuitable case for electric treatments. It was requested, however, that the case should be tested. Therefore the patient was seated in the operating chair, and the electrodes applied in the usual manner, the one to the nerve *medianus*, and the other to the flexor muscles of the paralyzed forearm; for nearly all these flexors were totally helpless. Instantly the contact was made with the electro-magnetic machine, using a down-running current of only one third strength, and the fingers were successively contracted as the lower electrode was swept transversely across the lower portion of the bellies of the adductor muscles. But they remained as helpless as ever so soon as the current was discontinued. The same prompt response of the still delinquent muscles of the affected leg was shown to the same moderate current. The test was then removed to the sound side, and there gave very similar results. Of course, this completely confirmed my suspicions, which led me to *pro*scribe utterly all electric treatments as being too hazardous for a patient while in such a state.

In the "early treatment" of hemiplegia *from softening of the brain*, Dr. J. Hughs Bennett, of Edinburgh, believes that the most important result for the practitioner to aim at, in these cases, is *to keep down the undue frequency and force of the heart's action*. To this end, he advises the strict maintenance of the reclining posture; and when the patient is awake and conscious, the mind should be tranquillized by every possible means. He says, again, "You will often be early consulted as to 'some expedient for promoting the restoration of the paralyzed limbs to their natural condition.' To this question, after having given a fair trial to the various means which have been proposed, (in the earlier stages,) I must reply, that I know of nothing

which more decidedly benefits the paralyzed limbs than a regulated system of *exercise* — active, when the patient is capable of it; *passive*, if otherwise. As to the use of electricity, which is now much in vogue, or the treatment by strychnia, which has been recommended, I feel satisfied, as the result of a long experience, that the former requires to be used with much caution, and that the latter is very apt to do mischief, and never does good. I have seen cases in which, after the early employment of electricity for some time, that agent has apparently brought on pain in the head, and has excited something like an inflammatory process in the brain. And so strychnine also will induce an analogous condition of brain, and will *increase* the rigidity of the paralyzed muscles." (See pp. 460–462, *Rules* 1, 5.)

### *Spinal Palsy. — Paraplegia.*

Paraplegia, we know, is a loss of the power of motion in the lower limbs, either partial or complete, and usually attended with inaction of the urinary bladder and rectum, with loss of power over the sphincters, and often with impairment or entire loss of sensation. When the affection arises from an injury of the spinal cord, the accession is sudden; but if from inflammation and its sequels in the spinal marrow or its membranes, or if the bones or cartilages of the spine are diseased, then the first appearance of the paralysis is more *gradual*. In this latter, there is first some abnormal sensation, which is soon followed by numbness, and this *by diminished power of motion in the lower extremities*, so that one easily trips; cannot stand long; has a sensation of weight in the limbs, and pains down to the feet.

*Paraplegia* is, then, a palsy of the lower half of the body, and is usually limited to the lower extremities; thus differing from *hemiplegia*, a palsy of a lateral or longitudinal half of the body, involving one arm and one leg. Paraplegia rarely depends upon cerebral disease; its most frequent cause being a lesion of the spinal cord. Many cases of paraplegia do occur, however, which seem to be the result of poisons, great fatigue, excesses, and from reflex causes, especially from those arising in the genito-urinary organs. It is a malady that may occur suddenly, but

usually it comes on slowly. At first the patient only loses the steadiness of his gait; then gradually he is deprived of all power of locomotion.

If the paraplegia results from a spinal source, and the lesion be in the lumbar part of the cord, the paralysis is confined to the lower extremities, and to the pelvic muscles. If the dorsal portion be affected, we have, in addition, signs of paralysis of the abdominal walls, and of the sphincters. If the cervical, or even the upper portion of the dorsal region be involved, there is coexisting palsy of the upper extremities, with difficulty in deglutition and respiration. One limb is usually more completely paralyzed than the other, and the loss of motion is accompanied with partial, or complete and permanent anæsthesia in the lower limbs. "If the spinal lesion is limited to a lateral segment of any part of the cord, as often occurs, then there is palsy of motion in the leg on the same side, (right or left,) and palsy of sensation on the opposite side." *

*Inflammation of the meninges*, or coverings of the spinal cord, termed *spinal meningitis*, is attended with very *severe pain*, which is increased by every movement. There is also the sensation of a bandage being fixed tight around the abdomen or waist. This sensation of stricture, or tightness, is often very distressing; as also the pains in the limbs, and the muscular contractions, which are more or less permanent and painful; although the palsy is but partial, or perhaps none at all, at this stage of the disease, while there is actual cutaneous hyperæsthesia. For recent acute cases, the treatment must be strictly antiphlogistic; with ergot, followed by argenti nitras, and the mercurials, alternated with the iodide and bromide of potassium, aided by posture, the patient lying with his face and stomach downwards, or at least *not* on his back.

*Effusion and compression* of the spinal cord may be the sequel of a previous inflammation; or may arise from other causes, as from sitting or lying on the damp ground. If decided paraplegia follows the occurrence of fatigue and exposure to cold and wet, or *follows* the symptoms mentioned under the head of

* Brown-Sequard's Lectures on the Nervous Centres.

inflammation of the meninges of the cord, then we may well suspect that an effusion has taken place, which compresses the spinal cord. Here we must apply blisters, and give tonics in small doses with mercury and iodine internally.

*Inflammation of the substance of the spinal marrow*, termed *spinal myelitis*, if not very acute, is attended with gradually increasing palsy of the lower limbs, which sooner or later becomes most complete. The *palsy of sensation* in the legs is also pretty sure to occur, but not very likely to be attended with muscle contractions, while we frequently notice priapism. In chronic cases, reflex movements in the palsied limbs are gradually lost, and no tickling, hot iron, nor electricity can any longer arouse involuntary muscular action in them. In all these cases of inflammation, congestion, effusion, and compression of the spine, if electricity is powerfully and repeatedly applied, it will do only harm. Wait for the proper time.

The usual consequences of actual inflammation of the spinal cord, or of its membranes, we know, are effusion of coagulable lymph, induration of the substance of the cord, either from the inflammation, or from impaired nutrition, or from loss of vitality. This is very often followed by palsy, atrophy, and rigidity in the legs. There may be also other results, from an inflammation affecting the vertebral or the inter-vertebral substance, as caries, exostosis, anchylosis, &c.,—any of these are often the pathological causes of the existing paraplegia; the chief characteristic of which is mainly the *loss of voluntary motion*, while involuntary motions, and spasms of the lower limb muscles, are not infrequent. If the lesion is situated high in the spine, then spasmodic contractions, more or less permanent, may now and then seize the abdominal muscles, as also those of the lower limbs. Now, these involuntary motions, pains, and spasms are manifestly caused *by the still existing irritation or inflammation in the cord*, or in its membranes; or of the roots of the nerves from extravasated blood, effused pus, from caries, displaced bone, &c. In the more severe cases from injury, the urinary affection continues, and hastens on the fatal issue; but in all others, the power of passing and retaining the water is restored in some degree, and *this improvement* is one of the chief indications of

the susceptibility of the cord to the restoration of its functions. The bowels, in these cases, are not only torpid, but the evacuations are very dark, and *often of a greenish, tar-like* appearance, and all the more so the higher in the cord is the seat of the lesion.

*The diagnosis* of a paraplegia, which is caused by true myelitis, is pretty clear. In these cases we always find muscle *twitchings*, and usually spasms in the lower limbs, or in the back, or both; as also *numbness*, and very frequently more or less *anæsthesia; pains* existing spontaneously, or easily produced by external excitation, as by pressure, percussion, or movements of spine; or by the application of a piece of ice, or heat along the spine; and by sensations of heat, or coldness, or pins-and-needles, or the crawling of insects over the legs. This paralysis is not always, but is usually complete; and the relative degree in the various muscles of the affected limb is *uniform*, or very nearly equal. Other parts are paralyzed besides the lower limbs; the bladder and the rectum are usually completely paralyzed, or nearly so, but this occurs *after* the paralysis sets in; and there is almost always a gradual extension of the paralysis upwards. Besides, there is a feeling as if a cord were drawn tightly around the body over the abdomen or thorax, marking out *just where is the upper* limit of the paralyzing lesion in the spine. The reflex power may be exalted, or abolished. If the myelitis has extended up to, or is seated in the upper portion of the cord, respiration, digestion, and other gastric derangements, are to be expected. The *prognosis* in such cases may usually be a slow and gradual progress towards a fatal issue; for, under the best treatment and care, only rarely do we see a complete cure. If, through ignorance, electricity is actively and repeatedly applied as a treatment, it will hasten the fatal result.

In teaching the deeper knowledge of physiology, and showing the evidences of different spinal diseases, Dr. Brown-Sequard has demonstrated that the spinal cord, in its most central part, which is decidedly insensible and inexcitable in its normal healthy state, may become exquisitely sensitive and excitable under the influence of inflammation or congestion; and that when the gray matter has become sensitive, it may occasion all those

strange sensations and other symptoms complained of by patients attacked with either myelitis, or great congestion of the gray matter, viz., pricking as by pins-and-needles, formication, itching, feeling of heavy pressure, or tightness, coldness, or heat, &c.; and jerks, trembling, cramps, convulsions, contractions, &c. In cases of paraplegia, *this group* of symptoms is generally due to a special alteration in the condition of the spinal cord; and the part of this group that concerns sensation, cannot be produced without congestion or inflammation; and is essentially characteristic of these two diseases, especially the latter; and if you do not find them in cases of paraplegia, you may be convinced that the spinal cord is free from congestion, and still more free from inflammation. This is very important to be ascertained, in the beginning of the treatment of a case, as regards the propriety or impropriety of using electricity.

*Spinal palsy*, we see, is most generally a *paraplegia;* but often only one leg is paralyzed. Where this paralysis is still depending on, or is attended with, active inflammation, congestion, or pressure from effusion in the spinal cord, it requires other means to reduce the disease in the spinal column; there being here no indication whatever for electricity in any form. But, this palsy having originated thus, and the causing disease in the spine having been already reduced; or where the palsy is the result of injury or wound of the back which is recovered from, and if still the palsy persists, electricity directed to the palsied muscles and their supplying nerves, by proper methods, is of the greatest service. It should be persevered in, and aided, perhaps, by quinine and strychnine in very small doses.

*The diagnosis*, in spinal palsy, *will show a complete loss of electro-muscular contractibility, with diminished sensibility.* If there is still existing an irritative lesion in the spine, then the same rule applies as in irritative brain palsy, so fully explained. Moreover, in this case, too, we see reflex *cramps* or *twitchings* of the leg, or of some of the leg muscles, on the application of a smart current, although there may be no direct muscle contraction where the electrode is applied. This is very important to be ascertained; for on *it*, depends the whole course of treatment to be pursued. There may be cases, however, where sen-

sation and voluntary motion are lost in the lower extremities, in which the spine *is not* diseased; but the paralyzing cause here is local, or is in the nerve cords; so as to *intercept* the communications with the brain; and very many of these cases are curable by the electric influence. But let us first look more closely into this large and very important division of palsies, and try to analyze the difference in causes and conditions of the different, yet seemingly similar cases.

*Congestion* of the spinal cord, causing paraplegia, is usually attended with a *dull* pain, that is generally confined to the lumbar and sacral regions: the palsy, in such a case, is preceded by a sensation of numbness, which progresses slowly from below upward; is but partial, and not usually attended with paralysis of the sphincters. The causes are said to be various; as due to mal-circulation, or from rheumatism, prolonged labor, fevers, or from exposure to cold and wet, or is reflected from the abdominal viscera.

*Gradual paraplegia*, or palsy of the legs, may therefore be caused by congestion of the spinal cord; or by acute or chronic inflammation of the meninges; in myelitis, by compression of the cord, or from softening, atrophy, or from reflex irritation; but which of these, in a given case, is the only or main cause of the palsy, we cannot always tell with certainty. But let us see.

*Sudden paraplegia*, which is very seldom met with, is usually the result of an injury to the spine, or is the result of *spinal hemorrhage*, (also termed spinal apoplexy;) or from some other sudden pressure, as diseased bone, or extravasated matter, or other injury. The diagnosis is aided by the history of the case; and by a careful examination of the back, aided by electricity, ice, and heat. If there be no history of an injury, if no sign of disease of the cord, bones, or cartilages, but if *violent pain* in the back, and the patient is unable to control his urine, or fæces, and particularly if the legs become rigid, we may judge pretty safely that a spinal hemorrhage has occurred; and this accident, we know, is prone to prove speedily fatal. Then there are cases of sudden paraplegia, where no cause can be assigned; while other cases evidently occur from sexual excesses, in whole or in

part, and others there are from a sudden giving way of the nervous mass after a long process of softening.

It has been shown by Dr. Brown-Sequard, that with improved diagnosis, a complete revolution in some departments of the practice of medicine has been made, within the past few years, by the study of experimental facts, observed upon living animals. Now, with this source of knowledge, together with that which is deduced from the comparison of those facts, with morbid cases in the human body, he says, "If we also appeal to the other branches of physiology, and to normal anatomy, especially to that of the nervous centres and of the nerves at the base of the brain, we shall find that to understand the symptoms of a large class of pathological cases, becomes almost as easy as to read the alphabet. In fact, many of the most complicated, the most obscure, and the most unintelligible cases of nervous disease, are as easily understood as the simplest case of bronchitis, or other simple affection of the lungs or bowels, if we but have the advantage of the light which experimental physiology and the anatomy of the base of the brain now afford." We cannot do better than to listen to this very high authority.

Suppose, for instance, a patient comes to us suffering from paralysis — an absolutely complete paralysis of the motion of one half of the body, from the neck downwards. Suppose that, in addition to this paralysis of motion, he has also, on the same side, extreme hyperæsthesia or increase of sensibility in all those parts which are struck with the paralysis of motion. Suppose we find not only extreme sensibility to touch, — a symptom which we may measure accurately with a pair of compasses or the æsthesiometer, — but also an extreme sensitiveness to tickling — a sensibility, by the way, quite distinct from the other. Let us suppose that we find, besides all this, that the sensibility to a prick or pinch — in fact the sensibility to painful impressions of every kind — likewise the sensitiveness to changes of temperature — cold and heat — is also much increased. Thus you have these four species of sensibility — each of which, I repeat, is entirely distinct from the others — all greatly increased in that limb, which, at the same time, is apparently dead, and it does not possess the least power of motion. Suppose, further, that in the

limbs and part of the trunk in that same side of the body, the temperature is found greatly increased; that the circulation of the blood on that side is more energetic, the arteries being fuller; or, in other words, that there is decidedly more blood there than elsewhere in the body.

If, now, we compare all these symptoms, which we observed to belong to one side of the body, — we will suppose it *the right*, — with what we find on the opposite side, they acquire still greater interest. On examining the *left* side of the body, we find an absolutely reverse condition. Here all the four species of sensibility, of which I have spoken, are lost — absolutely gone — on that left side. We find that there is, on that last side, a complete power of motion, and not the slightest diminution of the power of the will. Now, suppose we go further, and inquire into the condition of the *fifth* kind of sensibility, (assuming that their number is only *five*;) if we look for *the special sensibility in the muscles*, — that sensibility which serves to the direction of our movements, — we find that this peculiar sensibility remains perfect in the limbs of the left side; and that the notions of weight, of resistance, &c., derived from the muscular sense, also remain perfect in those otherwise anæsthetic parts. There is, therefore, on the *left* side, a complete anæsthesia of the four first kinds of sensibility of which I have spoken, but a persistence of the muscular sense; while on the *right* side, the condition is exactly the reverse — the muscular sense is gone, and the other four species of sensibility exist in a greatly *increased* degree.

But what about the degree of heat in the limbs of the left side, and what of the circulation? Here, too, the condition of things is reversed; for on the left side there is not only a degree of heat much inferior to that on the right side of the body, but there is also an actual diminution of heat if you compare the state of those parts with their normal condition; in other words, there is an *absolute*, not simply a relative, diminution of heat on the left side.

Thus, on the right side the temperature of the body has increased, while on the left it has diminished. The case is similar

as regards the circulation, which is less full in the left side than in a normal state. These features are striking enough; yet there will be many others in the same individual upon which I cannot now dwell, but which are fully as interesting, and equally difficult of explanation by the practitioner who is not perfectly *au courant* with the present state of physiological science.

*For example*, in the face, on the right side of the injury, (admitting that an injury is the cause of these symptoms,) there will be an increase of heat, an increase of sensibility, a contraction of the pupil, and a degree of occlusion of the eyelids; so that the eyes of the patient, if you look at them both at the same time while open, are quite different one from the other. The eye on the side of the increased heat and hyperæsthesia seems smaller, because the opening of the eyelids is smaller than on the other side. Just these effects we can produce in animals very easily; and I have seen the same in the human family. Now, what was the injury which produced all these remarkable effects? It was simply this: *a complete transversal division of the right lateral half of the spinal cord in the neck;* not simply a part, but, I repeat, the entire lateral half, i. e., the posterior column, the lateral column, the anterior column, and the gray matter of that side, and of that side only, had all been divided transversely and completely. Owing to that injury all those symptoms existed. This grand experiment the author saw beautifully illustrated by Dr. Brown-Sequard, before a large class of students in the amphitheatre of the medical department of Harvard University. But to quote this masterly teacher further: —

"Now, I ask you, if any physician at the beginning of this century, not having the light afforded by the present state of physiological science, no matter how learned and able in other respects, — had such a good living problem been presented to him, would he have been able to understand such a case? Decidedly not. Nay, more: he would, in all probability, not have seen the case as I have described it. He would not have recognized the existence of some of the symptoms. He would likely have fallen into the same error as was committed by the great French surgeon Boyer, who had such a case, but who never found that *the sensibility was lost* on that side which was still

under the power of the will, until the nurse, who discovered the fact by a mere chance, told him of it. From such facts you will see the great importance of a thorough knowledge of physiology. The learned physiologist can have no difficulty in understanding such a case; for when he knows that the spinal cord is the organ conveying *the orders of the will* to the muscles, — that the *motor* nerve-fibres, serving for voluntary movement, proceed along the spinal cord, so that those which serve for movement of the muscles and limbs on the right side of the body pass along the right side of the cord, while those serving for movement of the limbs on the *left* side of the body pass along the *left* side of the cord, — it is quite evident to him that such a division of the cord as I have described will cause loss of motion on one side, and not on the other. Again, the *sensitive* nerve-fibres which serve to the four first kinds of sensibility of which I have spoken, proceed in the spinal cord in such a manner, as to go into the *opposite* side of that organ from that side of the body from which they convey the sensitive impressions; so that the nerve-fibres of sensibility in my right arm and right leg, for instance, pass into the left side of my spinal cord, and *vice versa*. Hence, a division of the cord produces loss of sensibility on the side of the body *opposite* to that of the injury."

The explanation of the *increase of heat* in the limbs on the side of the injury, is equally simple. The nerves of blood-vessels, called vaso-motor nerves, pass into the spinal cord on the same side as that of the limbs into which they go; just as is the case for the nerves of voluntary movement, so that a division of the spinal cord on the right side produces paralysis of the nerves of blood-vessels in the right side of the body; in consequence of which, the impulse of the heart being less resisted on that side than on the other, there is a greater afflux of blood; and also (as an effect of this increased quantity of blood) an increased heat, and (as a consequence of both the increased heat and the augmented quantity of blood) in a measure, also, the increased sensibility of which I have spoken, the resulting hyperæsthesia of the four kinds of sensibility.

I will now produce another case. Let us suppose a man has received an injury, not of the half of the spinal cord, but an

injury of one half of the medulla oblongata at the level of the decussation of the anterior pyramids; not such an injury as would destroy life at once, but an injury, a tumor, or a morbid alteration, of sufficient extent to produce decided symptoms. In this case you would have all the symptoms which I have described in the former case, but with this difference—that as the anterior pyramids decussate there, an injury on the right half of the medulla oblongata would strike the fibres of voluntary movement belonging to that side, previous to their making their decussation; or, in other words, before they pass from the right side to the left side; and it would also strike the fibres of voluntary movement that have come from the left side, and have already made their decussation. In this case, therefore, there would be paralysis of motion on *both* sides of the body; while, as regards the state of the blood-vessels, as also the hyperæsthesia and the anæsthesia of the various kinds of sensibility, everything would be the same as in the former case.

Other striking differences we shall find, if we now take a case of injury a little higher up. A patient, I suppose, comes to you with paralysis of the external rectus muscle of the eye on the left side. The face is also paralyzed on the same side. There is, besides, anæsthesia of the face on that side; while the left side of the body is affected with paralysis, *both* of sensibility and motion. Here, then, is a case absolutely distinct from both the others. One most striking feature or symptom we must notice. You will often find, in such cases, that the tongue of the patient is perfectly free; there is no loss of movement at all in that organ, and there is no impediment of speech. You will often find that the facial paralysis is exactly the same kind as that which takes place when the facial nerve, outside the cranium, has been injured; i. e., the muscles which give expression to the face, and the orbicularis palpebrarum, are paralyzed. This case, therefore, is quite distinct from cases of hemiplegia arising from disease of the brain. As you are aware, in cases of paralysis arising from injury to the brain, the paralysis of the face is on the same side with the palsy of the body; and the orbicularis is *not* paralyzed, while the tongue is almost always somewhat paralyzed. In the case I am now speaking of, the distinction is

striking — the drawing of the face on one side, owing to the paralysis of the other side, because the paralyzed side of the face is the opposite to that which is usually paralyzed. Besides all this, you will find that the sense of taste is altered, in a good degree, in a part of the tongue on the side at which the face is anæsthetic. You will find, further, that the patient is in a state of considerable emotion: he will shed tears easily; he will gape repeatedly; and while gaping there will frequently be a sudden jerk of the paralyzed limbs. There are generally, also, considerable giddiness and tendency to vomit. I have now mentioned only the principal symptoms of disease or lesion of the upper part of the medulla oblongata.

Injury of the *pons Varolii* gives the symptoms I have just described; an injury striking at the same time one side of the trigeminal and of the facial nerves, before they have made their decussation, which is at the lower part of the pons Varolii, and striking also one side of the sixth pair of nerves before it has made its decussation with its fellow of the other side; thus producing paralysis on the side of the injury, just as if the injury existed in the nerve itself. You must not, however, suppose that an alteration of the pons Varolii will, under all circumstances, produce these effects. If the injury is a little higher up, than the lower part of this organ, striking at the place where the facial nerve and part of the trigeminal nerve make their crossing, you will have these results: *both* sides of the face will be paralyzed as regards sensibility and motion, together with the action of the external recti of the eye, also the sense of taste in the anterior part of the tongue, while the paralysis of sensibility and motion in the body and limbs will be only on one side. In order to understand this, it is quite sufficient to keep in view what the nerves of the face do when they reach the pons Varolii. When the injury strikes that nervous centre above the decussation, you will have, so far as regards the portions of the face and body which are paralyzed, the same effects as are observable in most cases of brain disease, viz., the paralysis of the face will be on the same side with the paralysis of the body and limbs. If, on the other hand, as

already stated, the injury strikes the pons Varolii below the decussation, the opposite effects are produced. How can we know, then, whether the seat of the disease is in the pons, if we have not that peculiar symptom of the difference of the sides, as regards the paralysis of the face and that of the body? Dr. Brown-Sequard says,* "There are several peculiar features, but only one of which will answer that question. In the first place, if the injury is in the pons Varolii, you will find in the beginning of the affection one most important symptom, viz., extreme *coldness* of that side of the body which is to become paralyzed after a time,—just the reverse of what will occur when the paralysis is complete, owing to a spasmodic contraction of blood-vessels preceding their paralysis and dilatation. If, together with this extreme coldness in one half of the body and limbs, there appear some tingling in the fingers, a very slight ptosis of the external rectus, some jerks in the muscles of the face, on the side opposite to that of the injury, also some sensations of tickling in the face, (these two last symptoms you do not find when the injury is higher up than the pons Varolii,) the disease or injury is certainly in the pons; for really with this class of cases doubt is impossible when the symptoms are combined, forming a group so definite and distinct that there is absolute certainty, even during life, as to their cause. It is not so when the disease goes higher up in the brain; we are then often at a loss, and it is extremely difficult to say, even, whether there is organic disease, or mere temporary disorder of the circulation; and still less is it possible to say what part of the brain is the seat of the disease.

"There is one kind of *hemiplegia* perfectly distinct from all those which I have mentioned. We will suppose a patient comes to you with some slight stiffness and tendency to throw his limbs in a wrong way when he walks. There is not a very great paralysis, but rather a decided weakness, and hardly any loss of sensibility on either side of the body. He complains, also, of noises in the ear on that side; of feeling extremely giddy; and of having sometimes a tendency to turn round upon himself, like a top. Sometimes he reels, as if he was intoxi-

* In his Lectures.

cated. He very frequently finds it impossible to walk straight forward. Sometimes, also, he has very great hyperæsthesia to sound; at times, also, he has a sudden tendency to fall down — it seems to him as if he cannot keep up, and that he must fall; also, that if he takes hold of something he will keep up. Now, this class of paralysis is one of the most instructive of all kinds of hemiplegia. I have collected more than twenty such cases. According to the autopsy, they are simply instances of reflex paralysis; not paralysis arising from the alteration or destruction, nor, in fact, from any interruption of the conductors of voluntary motion; the paralysis in these cases is due to quite another cause. In this class there is disease either of the petrous bone, or of the base of the brain near the origin of the fifth pair of nerves, or near the place of entrance of the auditory nerve. There is in this case not a destruction, but an irritation by a pressure on the *crus cerebelli*, or on a small part of the pons Varolii, or the medulla oblongata. Place a tumor there which has encroached slightly and gradually on the parts of the base of the brain I have named, and the symptoms just mentioned will appear. But let the injury go farther, and the paralysis on one side of the body, viz., the side where the injury exists, will *disappear;* and yet the injury to the brain is greater now than it was before. From the moment that a real disorganization has taken place in the base of the brain, the symptoms which existed at first disappear, and the paralysis passes from the right side of the body to the left side, the tumor being at the right side. But why?

"At first, in such a case, there is an *irritation* starting from the injured part or parts, acting as any other cause of reflex paralysis. Acting thus upon the brain, it causes a change to which is due the paralysis. But why, if the disease progresses, does the paralysis disappear on the side first affected, and appear on the opposite side? The explanation is this: The part which, in the first place, was irritated, has now been destroyed altogether; there is no more irritation, and the paralysis, consequently, ceases on that side; but it passes to the other side of the body because in the pons and medulla there are conductors of voluntary motion passing above their decussation, to go up to the

brain; hence, if any injury destroys some of these conductors, there will be paralysis on the opposite side of the body.

"One other species, of the several types of hemiplegia, is that due to hemorrhage (apoplexy) in the cerebellum. In such a case there are features that lead to accurate diagnosis. One of these symptoms is vomiting; this is a constant feature of hemorrhage in the cerebellum. There may be also hyperæsthesia in some parts of the body — not the whole body, or even half, but in some portions. There will often be amaurosis; this is generally due, not to pressure, but to *a reflex action*, as in a majority of cases no pressure is found. In many cases we may find the amaurosis existing in the left eye alone, in the right eye alone, or in both eyes, or passing alternately from one eye to the other in the same patient; although in all these cases the disease was only in one half of the cerebellum — showing, in fact, that there is no persistency or uniformity of action, in these cases, causing amaurosis; but this symptom of amaurosis, I hold, is due to reflex influence."

Another kind of hemiplegia is that due to a lesion of the anterior lobes of the brain. Dr. Brown-Sequard says, "Phrenologists, you know, have regarded the anterior lobes as the organs of speech; but there have been many instances in which there has been destruction of these parts without any deprivation of speech. But the question remains, after all, (and it is an interesting one,) What, in these cases, occasions the loss of speech when it does occur? A great variety of symptoms may be produced by a lesion of almost any part of the brain. *The loss of speech from brain lesion I hold to be simply a reflex phenomenon.*" We have almost a proof of this in the fact that it often varies very much in the same patient, and that while the brain lesion still continues unaltered. The loss of speech is usually without any loss of movement in the tongue; for there may be perfect freedom of motion in the tongue, yet the patient is *unable to give expression to his thoughts;* and this inability may be extended, so that he is equally powerless to express ideas, either by signs or by writing. The paralysis, in fact, is a paralysis of the organ for expression of ideas; and this may occur while the patient may remain, in other respects, in full posses-

sion of his intellectual faculties, so far as we are able to discover. It is not aphonia, but a reflex palsy of speech from brain irritation, and *not* to be treated by electricity.

*Chronic Inflammation in the Dorsal Region of the Spinal Cord.* — The characteristic symptoms of paraplegia from this *local myelitis*, according to Dr. Brown-Sequard,* are, —

A constant pain at the part of the spine at or over the upper limit of the inflammation in the cord.

Whether a constant pain exists in a very marked degree or not, it is almost always found that pressure upon the spinous processes of the vertebræ, when made at the upper limit of the inflammation, causes an acute pain.

The passage of a sponge or folded cloth, filled with quite warm water, along the spine, gives a normal sensation of heat in all the parts above the seat of the inflammation, but *a burning sensation* when just *at its upper limit.*

The passage of a small lump of ice along the spine gives the natural sensation of cold every where, *except at the level of the inflammation*, where the sensation is that of *burning*.

Most patients complain much, but some others less, of a sensation as if there were a cord, or some other ligature, tied around the body at the upper limit of the paralysis. This is probably a cramp in the muscles of the abdomen or chest.

Various singular sensations, resembling very much those which follow the pressure upon a nerve, such as formication, pricking of pins-and-needles, or of burning, or intense cold in the feet, legs, and thighs; but less frequently in the body. During all this stage, electricity is contra-indicated.

*Softening, and atrophy* of the spinal cord, causing paraplegia, cannot very certainly be diagnosed from each other, or from chronic inflammation; but softening, we know, often is the sequel of the latter. Atrophy of the cord may be suspected, if the patient has been long subject to tremulous movements, and an unsteady gait; or if the failing strength, and sensation in the legs, as well as the gradual loss of motion, are *preceded* by spasmodic muscular contractions, or sudden muscular jerks, which

* See his admirable *Lectures on Paraplegia*, p. 63.

are sometimes painful, and sometimes, yes, oftentimes, mistaken, at the time, for neuralgia. But in paraplegia caused by *tumors* of various descriptions, especially those of a cancerous nature, there is more decided anæsthesia, or perverted sensations in the lower limbs, with evident signs of constitutional disease, as marked emaciation, debility, and difficulty in urination, with priapism, great pains, and a gradually increasing paralysis.

*Case of Softening of the Spinal Cord.* — From the country a poor cripple was brought for treatment, who had suffered loss of power to move the upper and lower limbs for over thirteen years. The palsy at first had come on suddenly in the night. For very many years the thighs had been firmly abducted and the legs flexed. The arms and hands were feminine, flaccid, plump, and soft. No pulsation in the arteries of the lower limbs, while the pulse at the wrist was so fine and faint, that it seemed more like that of a feeble infant. The temperature was not diminished; bed-sores had long troubled him on his rump; and of late sphacelus had come on along the shin bones. Of course it was utterly impossible for me to undertake to do any thing, in the way of treatment, for the poor fellow. I sent him home. The next spring, nearly a year after, I received the following sketch, condensed from the report by Dr. Johnson, the physician of the place: —

*Post Mortem.* — "The anterior columns of the spinal cord were softened, and white as milk, from the fifth cervical to the second lumbar, and it was almost as fluid as cream; no extravasation of blood in nor about the cord. The brain was atrophied; the muscles nearly all in a yellowish, fatty state, but to appearance almost as full and large in form, before removing the skin, as natural; but what was very noticeable, the deltoid and triceps muscles of the arms, and the sartorius muscles of the thighs, were the least affected of all the muscular system."

To illustrate the difference in the symptoms, the diagnostic *evidence* between *irritation* and "*solution of continuity*," in the spinal cord, we give the following graphic demonstration by Dr. E. Brown-Sequard. He says, "Suppose two patients are brought to you, each having sustained an injury by fracture in the cervical region of the spine, and each having, in conse-

quence, a complete paralysis of the trunk and limbs. One of them is almost pulseless, extremely cold, and covered with a clammy sweat. He appears almost a dead man; there is no contraction of the muscles, the limbs hang loose and dead, his breathing almost gone, his pulse — not only very faint, but extremely slow — from forty to forty-five in a minute. If you commit the fault of bleeding him, you find that the venous blood flows out red, like arterial blood — it flows out, not with a great impulse, for the heart is very weak and almost in a state of syncope; but still it flows out not like venous blood — it has an impulse like arterial blood. Now examine the other patient. In him the symptoms are almost the exact contrary to all those just seen. The limbs are stiff and rigid; the pulse unnaturally high; the heart's action is much excited; the heat of the body is not only higher than is usual in the limbs, but is absolutely higher, and by many degrees, than the temperature of the blood in health in man. If you bleed him, which may prove useful, you find that the venous blood is darker than usual, and comes out without any trace of impulse.

"Now, what is the explanation of these two cases, so alike, and yet so very different? How is it that one of these patients is in a state of syncope, and the other in a state of asphyxia? It is found, by experiments upon animals, that in the former of these two cases, the cause is an irritation of the spinal cord, — perhaps extremely slight, for the slightest prick may be sufficient, — the effect of which is, a stoppage of the heart's action, so that it beats with diminished force and rapidity; and as a consequence of this induced condition of the heart, all the other symptoms above described ensue. In the other, latter patient, on the contrary, the spinal cord has actually been cut across altogether, and the patient is in a far *worse* state, in reality, though he *seems* to be far more alive than the other. He *seems* to have the power of reaction which we wish to find in patients; yet the danger of his state is far greater — in fact, he is sure to die; while the other, by means of an operation, (trephining, or resection of the spine,) may possibly survive."

Cases of paraplegia, with still existing disease of the spinal cord, even when the palsy is complete, i. e., is both of sensation

and motion, show us that such patients may be tormented with involuntary movements of the lower extremities, particularly at night, which not only prevent sleep, but occasion pain and distress. Completely palsied limbs, which in their quiescent state are immovable and insensible, may thus become active and painful. Why? The cause of this, no doubt, is owing to an accidental or periodical increase of the primary disease in the cord; an extension of the irritation, or state of excitement, from the point of lesion, or disease, to the whole cord; to the portion in connection with the brain, as well as that which is below the lesion. The simple gravitation of blood from posture can produce this; mental excitement, exercise, or some reflex influence may produce it.

The propagation, likewise, of the excited state of a diseased part of the brain, to that portion of the spinal cord which is more directly connected with it, and from which the nerves of the paralyzed parts arise, is seen manifested by the occasional, periodical, or constant rigid and contracted state of the muscles in the paralyzed limbs. The nerves themselves likewise partake in the irritation of the cord thus produced, and so keep the muscles in a continual state of active contraction. There is no organic lesion of the cord in these latter cases, at least not necessarily so, for its state of excitement — polarity — is dependent upon the transmitted cerebral irritation.

Sir Benjamin Brodie says he has not met with the attending symptom of *priapism* in any case where the seat of lesion was below the sixth dorsal vertebra. Another singular phenomenon, I have often observed, is that in the most profound, manifest, and complete paraplegias, the temperature of the palsied limbs is exalted; i. e., warmer than in health. This does not long continue, nor is it always present in such cases. When it does occur, however, I take it as a discouraging feature, as there will probably result, in spite of treatment, more or less atrophy and contraction in the burning muscles. But these, being facts, must not deter from early and gentle, but persevering efforts to save the limbs, all we can, by manual exercise; by counteracting with suitable apparatus the tendencies to mal-posture from the contractions; by exercising and thus nourishing the muscle fibres by

electricity, and *if cold, by keeping the entire legs and feet all the time warm.* Every hour they are allowed to remain cold the contraction and rigidity will be the greater. When, in a paraplegic affection, we discover that *anæsthesia prevails* over the loss of power, (i. e., is greater,) we must not in that case expect to find a local or circumscribed lesion of the spinal cord, but examine for a diseased action, or state, in some peripheral portions of the nervous system, *or whether there are not indications of a brain origin.* Which of these two causes prevails, the general history of the case will aid us in deciding.

*Cervical paraplegia* occasionally occurs, manifesting itself in the upper extremities, the legs being more generally not in the least affected; while, if they should be involved, they are always much less so than the arms. The muscles of the shoulder and arm, and more particularly the right shoulder and arm, are first affected; and, not unfrequently, this is the whole of the affection. This disease sometimes attacks both arms at once, or begins in one, and so passes over to the other also. At first there are usually pain and soreness in the muscles involved; but after existing for a longer time, no modification of the skin sensation remains, but there then exists an obstinate paralysis, which probably commences in the muscle fibres themselves, *or through some perverted action* of the nerves of those parts; for there is *wasting* as well as *palsy.* For this employ Faradaization.

A sailor, just arrived, as second officer in the bark S., from the Mediterranean Sea, presented with paralysis of both arms, — complete in the right arm, but partial in the left, — produced by protracted *cold water affusions* for his fever, immediately after sailing from Smyrna. There were softness and atrophy of all the shoulder and arm muscles on the right, and those of the left doubtless tending to the same condition. For this otherwise nobly framed fellow I adopted localized Faradaization, or rather by my *team-electrodes*, as it were *bathed him with electricity* over the affected limbs, shoulder muscles, and the upper portion of the spine, by employing very brisk currents through labile (moving) electrodes. This was done daily, and in a fortnight he was quite restored.

Dr. Dewees states, as the result of his experience, that in paralysis resulting from the various affections of organic nerves, or where nutrition, local or general, is deficient, he prefers the primary current of the compound battery, applied in the *inverse* direction; but in "muscular palsy" the current should be directed *with* the nervous ramification.* He recommends, therefore, the sustained primary current, wherever it is desirable to exercise an organizing power over the affected part, but a resort to induction currents when more stimulation and exercise of the nerves and muscles are desired.

*In the diagnosis* of these cases, electricity comes to our aid; for sometimes we must be greatly perplexed to know if the palsy we are called to examine is the result of commencing disease of the brain, or of the spinal cord, or whether it is reflex, or is complicated, or is simply and purely local. In general cerebral paralysis the electro-muscular contractility is wholly intact. In general paralysis of spinal origin, *if complete*, this power of the battery is lost; no kind of electricity, whatever be its strength, and no effort of the patient, can possibly cause the stricken muscles or limbs to move.

In *general* palsy involving the mind, as also in the general palsy from progressive muscular atrophy, the affected muscles only feebly, or but partially, respond to electricity; but still they do respond; as long as there are some, if but very few sound muscle-fibres left, they respond distinctly. Rheumatic palsy, which is also sometimes attended with atrophy, is known from the fact that the affected muscles are in groups rather than one muscle, or one here and one there; and these affected muscles are *the seat of pain, which is increased by movement;* the electro-muscular contractility and sensibility are nearly natural, or, if any, but little diminished, until *late* in the disease, when the nerve becomes thus changed in structure.

Hysterical palsy may be known from this latter, (rheumatic,) because, in the hysterical, the electro-muscular *sensibility* is diminished or lost, while the electro-contractility remains intact. In the essential paralysis of childhood the muscles atrophy, and finally undergo fatty degeneration. But here we learn that the

* New York Journal of Medicine, May, 1847.

attack was sudden, or was attended with fever, gastric or cerebral symptoms, and we find no electro-muscular contractility, except, possibly, a very trifling degree in some few remaining muscle-fibres; while the surface of the skin over the affected muscles is at the same time most exquisitely sensitive to the electric stimulus; the skin of the affected parts is red or purple, and is usually too cold, or too warm, and is hyperæsthetic even to handling, squeezing, or the electric current.

While studying and treating the diseases of the nervous system, we shall do well to keep definitely before our minds the several leading propositions of recent systematic writers. We know that Dr. Marshall Hall lays down the hypothesis of an "*excito-motory system of nerves*," *and of a true spinal cord;* that is, as the centre of all physical nervous action. The various muscles and sentient surfaces of the body are, according to him, connected with the brain directly by nerve fibres which pass completely from one to the other. Those fibres destined for, or proceeding from, the trunk to the brain, pass along the spinal cord; so the cord is, in great part, according to him, no more than a bundle of nerve fibres, going to and from the brain, and these fibrils are specially for sensation and volition. And in addition to these, there is another class of nerve fibrils, according to Dr. Hall, proper to the spinal cord and its intracranial continuation, and which forms a connection with the gray matter of the cord. Of these fibres, some are afferent or "incident," while others are efferent or "reflex;" and these two kinds of nerves have an immediate, but unknown, relation to each other, so that each afferent has its proper efferent one, the former being the *excitor*, and the latter the *motor*. Now, the aggregate of all these fibres, together with the gray matter, says Dr. Hall, constitutes the *true spinal cord;* which, however, is not limited to the spinal canal, but passes up into the cranium as far as the *crura cerebri*. Moreover, these excitor and motor fibres are quite independent of those of sensation and volition, and of the *sensorium commune*, using that term as indicating the centre of intellectual actions, (as put forth by Prochaska.) Although these are bound up with sensitive and motor fibrils, yet they are not directly affected by them; and they maintain

their respective course in the nerve trunks as well as in the centres. But this hypothesis of Marshall Hall is not entirely accepted now as complete.

Another grand hypothesis, as laid down by Müller, Whytt, and other leading physiologists of the present day, is, that the nerve fibres of sensation and of volition, individually and immediately, proceed to and from some part, or parts, of the intracranial nervous mass, and that every nerve fibril in all the organism is precisely by itself continuous into the brain. Those which are distributed to the trunk, or extremities, pass along the spinal cord, and separate from it at the various roots of the nerves, as they leave the spine; and while in their course within the spine they mingle more or less with the vesicular matter of the cord. According to this hypothesis, there are no other nerve fibrils but these, (excepting the commissural,) and they are quite sufficient to manifest all the physical, as well as the mental, acts. Thus the nerves of sensation are capable of exciting the nerves of motion, which are in their neighborhood; and they may produce this effect, even, when the spinal cord has been severed from the brain; because their relation to the gray matter of the cord is such that their state of excitement, however varied, is readily extended to it. Neither is this hypothesis accepted in full, as such.

There is still another and more recent hypothesis put forth by Drs. Todd and Bowman, of London, which assumes that all the spinal and encephalic nerves, of whatever function, are *implanted in the gray matter of the segments of the cerebro-spinal centre*, with which they are severally connected, and *do not pass beyond*. The several segments of the cerebro-spinal axis are connected with each other through the continuity of the gray matter from one to another, and through the medium of *commissural fibres*, which pass between them. Motor or sensitive impulses, through these means, may be propagated from segment to segment; and a stimulus conveyed to any segment from the periphery may either simultaneously affect the train, and cause a sensation, or it may be reflected upon the motor nerves of that particular segment, and stimulate their depending muscles to contract. Or, indeed, both these effects may take place

at the same moment, as the result of one and the same stimulus. According to these gentlemen, each segment of the cord, so long as it retains its proper *commissural* connection with the brain, (by both commissural fibres and continuous gray matter,) is in fact, and effect, part and parcel of the centre of volition, as well as that of sensation; and the mind is as directly associated with each segment of the cord as it is with any portion of the encephalon. Just let that commissural connection be dissolved or severed, and the mind will immediately lose its hold upon the cord and its dependencies. But the various segments of that organ may, nevertheless, be acted upon still *by physical impulses*, and may still continue to evolve the nervous force in connection with the natural changes which may take place within.

An abstruse writer in the British and Foreign Medico-Chirurgical Review, remarks that the recent discovery of Mr. Grainger, viz., that from each root of a spinal nerve some fibrils are implanted into the gray substance of the cord, while others apparently become continuous with the longitudinal fibres of the cord, gives an argument in favor of the views of Dr. M. Hall. Moreover, it is distinctly understood that many anatomists still hold to the belief that some of the fibrils in each nerve root are continuous with the longitudinal fibrils of the cord; yet this by no means is evidence that they actually pass along the cord for any great portion of its length, far less that they pass upwards continuously to the gray matter of the cerebrum. Besides, there is a general agreement that the great bulk of the fibres which constitute the *roots* of the nerves of any segment of the spinal centre, are implanted in the gray matter of that segment, and do not pass beyond it. It is now shown, also, that the white matter of the cord does not increase in amount from below upwards, as it ought to do according to Dr. M. Hall's views, but is, in truth, greatest where there is the most ganglionic enlargement.

We notice another difficulty, arising from the doctrine of the "distinct and continuous nerve-fibre system," which has reference to the *emotional* actions. These actions were supposed by Marshall Hall to take place through the instrumentality of the

true spinal fibres; but this doctrine was objected to, by Dr. Carpenter, on the grounds that emotional actions may, and do, take place in parts which are paralyzed as to the *will*. Dr. Carpenter considered, therefore, that the emotions can only be excited through the sensations, and that chiefly through those of the *special* kind. He contended, finally, that we must recognize the existence of a *third class* of nerve fibres, having their special seat or centres in the ganglia of sense, and independent alike of the cerebral and of the spinal. Indeed, Dr. Copeland, as early as 1825, advanced the doctrine of a third class of nerves, which he conjectured to be *prolongations* of the ganglionic fibres, extending by such subtile ramifications into all parts of the body as to escape ocular demonstration, yet as evidently existing. Dr. Todd also recognizes the necessity of this extension of the theory of a "distinct and continuous nerve-fibre system," *if it be adopted at all;* but adds, "it is difficult to admit the existence of *three orders* of nerve fibrils in integument and muscle, which, to be effective, must all have the same relation to the elements of the muscles."

But if we now leave all these hypotheses, and look closely at demonstration, we see, concisely, two or three well-defined propositions, viz.: —

First, that the *brain*, or some part of it, is absolutely essential to the production of mental nervous actions; or, in other words, the actions of volition and sensation cannot take place without the brain.

Second, that the *vesicular* (gray matter) is the true dynamic nervous matter, and that which is absolutely essential to, and the *source* of, the development of all nervous power in human beings.

Third, we conclude that the anatomy of the spinal cord (as we now understand it) teaches us to regard each segment of it as the centre of its own proper nerves; all centripetal impressions being received in the first instance by it, and all motor impulses finally proceeding from it; and, at the same time, the connections established through *commissural* strands between the different segments of the cord itself, and between the cord on the one hand, and the cerebrum and cerebellum on

the other, the impressions first conveyed to the cord, are carried on to the sensorium, so as to produce sensations; whilst motor impulses originating in the cerebrum are brought to act upon the muscles, by being directed to the segment of the cord whence their nerves proceed. All muscular movements, whether reflex, emotional, or voluntary, *are immediately called into action* by the same class of sensory or efferent nerve fibres; moreover, the excitor or afferent fibres are at once in like manner the channels of the transmission of stimuli, which gives rise, in one instance, to *reflex* actions through the spinal cord, and of impressions, in another instance, that become sensations when transmitted to the sensorium. The mechanism, then, of a voluntary action in these parts that are supplied by spinal nerves would be the following:—

The impulse of volition, excited primarily in the brain, acts at the same time upon the gray matter of the cord, (through the fibres of the white substance of the brain, which radiate from the *thalami optici* and the *corpora striata*, or, according to Dr. Todd, simply through the strands of the *medulla oblongata*, especially the anterior pyramids,) and then from this gray matter of the cord, simultaneously upon the *anterior* roots of the nerves implanted in it. This gray matter, in virtue of its association with the brain by means of the fibres of the white substance of the brain, or the anterior pyramids, *becomes part and parcel of the organ of the "will,"* and therefore as distinctly amenable to acts of the mind, as that portion which is contained within the cranium. If we destroy the commissural connection with the brain through the pyramidal or white brain fibres, the spinal cord ceases to take part in or respond to mental nervous actions; or, if that connection be only *partially* destroyed, then precisely that portion of the cord, which the now injured nerve fibres had formerly associated with the brain, is no longer influenced by the mind.

Again, if the seat of volition in the brain be diseased, then the portion of the cord that corresponds to the seat of that lesion participates in the effects of the disease as far, at least, as regards *voluntary actions*. And again, we must bear in mind that a continuity of *fibrous* structure here is not

absolutely necessary for the transmission of nervous energy, or, as Dr. Todd would say, "*for the excitement of nervous polarity*," for there is ample evidence that the vesicular substance alone, here, may be subservient to this purpose. It has been fairly demonstrated, by Stilling, and Van Deen, "that both sensory and motor impressions can be communicated from one portion of the spinal cord to another, even after complete sections are made in such a manner as to leave the two portions of spinal cord only connected by the *gray* substance. In no other way, indeed, can we account for the *radiation* and multiplication of impressions in cases where there is a certain state of *exalted* (abnormal) polarity and activity of the "automatic" spinal centres.

*Paraplegias* of all grades, then, may be arranged in *three* classes, each category depending upon a lesion of a different kind, and each distinguished by symptoms of its own. We cannot do better than to give the condensed views of Dr. Gull, of Guy's Hospital, on this subject; and they are arranged much as follows: —

1. The first class of paraplegias *are those resulting from lesion of the spinal cord.* There may proceed, then, from this, a general paralysis of the parts below the injury, whether the lesion be confined to the anterior or posterior portion of the cord, or whether it extends through the entire substance of the spinal cord; and in either of these cases *there is greater loss of motion than of sensation*, the sensation, usually, being little, if at all, impaired, whilst the loss of motor power is complete; and this he considers to be almost invariably diagnostic of the spinal origin of the given case of paraplegia. He affirms that, after an attentive search, and having great facilities for this, he cannot find a case of uncomplicated pressure on the cord, or of disorganization of the cord, in which the *loss of sensation* predominated, or in which there was simply loss of sensation. He says, "My attention has now for years been much given to *post mortem* appearances; but I have not met with a case that does not confirm the foregoing, nor are there amongst the numerous cases of lesion of the spinal cord, which are in the records of this hospital, any which show that one part or

column of the cord, when affected, is attended with anæsthesia, without loss of motion, though, as we have seen, the loss of motion usually occurs without anæsthesia." But we must bear in mind, that in paraplegia from disease of and about the spinal cord, the spinal nerve roots, as they leave the cord on either side, are not unfrequently implicated near their junction with the cord. Thus, Dr. Abercrombie cites the case of Count de Lordat, which was a paralytic affection of the left arm, following an injury to the neck from a fall, and the opposite arm became *numb*. By the post mortem examination this was explained; for there was found, not only *induration* of the cord, but "a compact and tendinous condition *about the roots of those spinal nerves*, owing to a thickening of their investing membranes." The former produced the paralysis of motion, the latter the numbness. There are also, now and then, cases of *cervical* paralysis, which see under that head.

2. The *second class* of paraplegias are those in which the loss of *sensation* is greater than that of motion. The cases under this category naturally arrange themselves into two groups, according to their seat of lesion; the one being *peripheral*, affecting the nerve trunks in their course; the other being *central*, and in that case it is *encephalic* instead of spinal. These form the second and third classes. The first group, where the cause is peripheral, is the *second class* as reckoned by Dr. Gull; while the second group, which is caused by brain lesion, makes the third class. The second class, then, *are known by the preponderating anæsthesia arising from peripheral causes*. As the grandest example in this (second) class of paraplegic diseases, is quoted the *epidemic of Paris*, in the spring of 1828, so graphically described by Dr. Chomel. This curious affection usually set in with an extraordinary and exquisite *exaltation* of the general sensibility, which, however, gave place, after a few hours or days, to a general *diminution* of sensibility, and this proceeded even to the extent of a complete *abolition* of sensation. The power of motion also declined, but in a far less degree. In most of these numerous cases, recovery took place, although the palsy was very capricious — sometimes self-vanishing, and then again reappearing. In some cases, however, the disease went on to a fatal

termination. This wide-spread disease had all the characteristics of a malady induced by the presence of some poisonous agent in the blood. *Prevailing numbness* is then the characteristic of this class.

3. The *third class* of paraplegic diseases, already partially defined under the second class, are to be recognized also both by their diminished vitality, and *peculiarly* diminished nerve force. These are the cases that result mainly from anxiety, deep mental depression, irregular practices, &c., which are attended with general diminution of the encephalic and other nervous forces. In these there is a greater proportional impairment of sensation than in spinal affections. Whatever impairment of the power of voluntary motion there may be, is often in a greater degree *owing to the want of the guiding influence of sensation*, (muscular sensation?) than to any direct loss of motor power. Therefore the gait of such persons will be found to be very much like that of a drunken man. Where the anæsthesia in these cases is complete, the person is obliged to employ the *visual sense* to enable him to walk at all without stumbling, as a substitute for the "muscular sense." Thus, says Dr. Gull, "one patient told me he could not walk without looking down at his feet all the time, because he felt as if his legs were cut off below the knees. Another patient said he had to do so because he had no apparent weight."

A large number of these cases not only "had no sensation of weight," but they have so frequently complained to me of their suffering when awake, walking, or asleep, from the *sensation of rising*, and being unable to keep their feet down on the ground or floor. This sensation, by times, harasses these patients prodigiously. As they recover, this vanishes. When this *peculiar* sensation appears in a less degree, however, then it is described by the patient as if the limb was covered with a glove or stocking, and as if the impression was outside of this. Notwithstanding the numbness, there is still the perception from pricking or pinching of the integuments; and what is particularly noticeable, this numbness often extends only to about the elbows, and as far as the knees.

Moreover, there are frequently, *in these cases*, affections of

the special sense, as flashes of light, *muscæ volitantes*, dimness of vision, and noises in the ear. One other peculiarity noticed by Dr. Gull, and which I can verify, is, that the most moderate pressure on any of the nerve trunks, as simply from lying on the arm in bed, or sitting upon the edge of a chair, or the like, will very readily render the nerve so compressed, completely anæsthetic, with deep and painful prickle, which often renders the limb helpless, at least for a very short time. This symptom is evidently from delicate constitutional structure, or from exhausted or attenuated nerves. That the seat of this threatening affection is encephalic, rather than spinal or peripheral, appears scarcely questionable; and that its cause is rather a delicate nerve structure, or a disordered state of the general nerve nutrition, than any sort of local lesion, is equally certain. Let the patient but avoid the mental *over-work*, or correct all evil habits, and electro-therapeutics, with other rational medication, can cure this nervous affection.

*Paraplegia from Urinary Causes.* — Diagnosis. This paralysis is reflex, and is always *preceded* by some affection of the urinary organs; as of the urethra, prostate gland, bladder, or kidneys; but the bladder and rectum are themselves rarely paralyzed, or only slightly so; as also there is usually obstinate gastric derangement — all of which are better or worse together. This paraplegia is usually incomplete, the lower limbs only are paralyzed, and some muscles are more paralyzed than others of the same limb or limbs, spasms in the muscles of the limbs very rare, in the back never; no anæsthesia, no sensations of the crawling of insects, (formication,) no abnormal feelings of heat or cold; nor prickings, nor pains in the spine, either spontaneous or caused by movement, percussion, pressure, heat, or ice, &c.; no gradual extension of the disease upwards, no feeling of pain or strictures around the body; reflex power in the legs is nearly natural. But there are great changes, at times, in the degree of the paralysis, corresponding to the changes in the disease of the urinary organs.

If the urinary disease is curable, so will the paraplegia be; and a cure often is speedily obtained on the amelioration or cure of the urinary affection. We must bear in mind here, however, that a urinary paraplegia may be simply a reflex paralysis, or it

may be *connected with* myelitis; the latter *producing*, at the same time, some alteration in the kidneys or bladder, as also the paraplegia; or the urinary affection may be acting upon the spinal cord by a morbid nervous reflex effect to produce the myelitis, and consequently the paraplegia. The history of *priority*, of classes of symptoms, must guide us.

Paraplegia may occasionally be due, then, to some *traumatic* or *reflex* cause, as from diseased teeth or teething, or from disease of the pleura, lungs, or bowels; as we often see instances in children. It may be due to pain in joints, or trunks of nerves; from rheumatism; from the womb, bladder, urethra, kidneys, or rectum accumulations; or from pressure on blood-vessels and nerves, as the obturator nerves, and the sacral plexus. The effects of treatment are sometimes evidence for confirming diagnosis in doubtful cases, for no treatment for spinal paraplegia seems to do any good while the pain or outside cause is not alleviated, or not entirely cured; but as soon as this is cured, the paralysis is easily cured also.

*Case of Paraplegia caused by Disease and Pain in Knee Joint.* — A medical gentleman, from New York, came under my care, who, in giving the history of his case, said that some time before his paraplegia came on he had hurt his knee by accidentally striking the inside of the knee joint against the step of his carriage while getting into it. This grew more and more painful from day to day, until the whole joint was diseased, stiffened, and painful. Soon after, the whole limb became paralyzed; and, finally, the pain in this knee ceased, and at once appeared in the other knee; and then that limb also became paralyzed. There was no disease of the urinary organs, nor of the spine, that I could find. He was therefore treated with electricity as for rheumatism. In three months' time he was cured, and returned to his professional duties.

*Paraplegia due to Teething.* — Dr. Brown-Sequard says, "I had a very interesting case of this kind, in which the paraplegia came in the beginning of the second dentition, in a boy five years old, increasing and decreasing alternately, at the time of, and after, the cutting of each of the molar teeth. In this case," he says, "there was a slight contraction in some of the paralyzed

muscles." Simple hygienic means, with galvanism and shampooing, and a decoction of cinchona bark, were early employed with complete success. Many such cases are on record.

In most cases where paraplegia arises from actual organic disease within the spinal sheath, there is, at some time or other, some degree of palsy of the intercostal muscles, or of the diaphragm. In general, the *pain* in these cases is referable to the base of the brain. But in some cases they refer the pain to the forehead, and are able to control the urine and fæces; sensation remains normal, while the palsy is only that of motion; and this would lead us to suppose that the spinal cord only is diseased, or else is compressed with effusion within the theca, which may gravitate towards the lower portion. Now, where there is no history of palsy of the diaphragm or intercostal muscles, I blame the kidneys, and put the patient immediately upon the mutual use of electro-magnetism to the back and loins, and the internal exhibition of tinc. cantharides in thirty-drop doses, repeated two or three times a day, and alternated with large draughts of lemonade made of the *acetate of potassium*, which, if followed with an increased flow of urine, will almost surely be followed by a recovery. If strangury should ensue, (and there is no existing stricture,) give twenty or thirty drops of laudanum, in a small starch injection, or camphor by the mouth, and it will immediately disappear. When the cantharides prescription is dropped, continue the daily or semi-weekly use of electricity to the spinal muscles, loins, and abdomen.

*Incomplete paralysis of the lower extremities*, according to the views of Dr. Spencer Wells, is often connected with diseases of the urinary organs, and may not be dependent on spinal disease. If a patient comes to you with a tottering gait, complaining of weakness in the knees, and a tendency to stumble on any uneven ground, exhibiting a certain loss of that muscular *consciousness* which enables us to walk without watching the feet to know where to place them at every step, your first impression will be, very naturally, that you have to deal with a case of spinal disease. Your first impression may be correct.

As you proceed with your examination of the case, you may find evidence of some kind of injury or disease about the spine, or possibly some proof that the disease is within the cranium. But in another case you may find nothing of the kind, and you are driven to assume a diseased condition of the lower portion of the cord, perhaps a simple atrophy. Now, let me convince you that you can have all these symptoms, that they may go on to complete paraplegia, and the patient may die, and that then you may find the cord perfectly healthy, so far as our examination can teach us, while the *kidneys* and bladder, either or both, are found the seat of manifest disease.

M. Rayer, in his great work on diseases of the kidneys, (vol. iii. p. 168,) says, "The development of paralysis after diseases of the urinary passages is even now a fact unknown to a great many physicians." As the condition of the urinary organs improves, so the recovery of power in the limbs is manifest; but in fatal cases there will grow all the appearances of severe inflammation of these organs, while the brain, cord, and vertebræ are perfectly healthy. So that while, on the one hand, disease of the urinary organs is constantly caused by paraplegia, so, on the other, paraplegia, through the sympathetic, is frequently consecutive to diseases of the urinary organs.

To enable us to distinguish this form of paraplegia from that depending on spinal disease, Dr. Wells says, we must first bear in mind the history of the case, and compare this with the history of injury or disease of the vertebræ, or intervertebral cartilages, or inflammation of the cord and its membranes, and bear in mind the following characteristics: —

1. There is found in "urinary paralysis" some impediment to the discharge of urine, as one of the earliest symptoms.

2. This is closely connected with some obstinate gastric derangement.

3. The weakness in the limbs is rather extreme debility than true paralysis.

4. The tactile skin sensibility is but slightly, if at all, impaired, while the *muscular sense* may be, and usually is, almost totally lost.

5. The limbs are tolerably well nourished; they may be thin, but there is no marked muscular atrophy, and their temperature is very little lowered.

6. The sphincter ani is not paralyzed, though it may be weak.

7. The bladder preserves *some degree* of contractility.

8. There may be no pain in the back, and no pain on pressing the spinous processes or on applying a hot, wet sponge to them.

9. The degree of weakness in the legs is in ratio to the urinary disease; catheterism, and any removal of obstruction to free discharge of urine, is sometimes rapidly followed by amendment.

10. In the *early stages* of this form of *partial* paraplegia, there is no history of convulsions, or of cramps, spasms, formication, nor violent neuralgic pain.

Take a case still more advanced. The patient can yet walk a mile or two, perhaps, but the gait is tottering; the urine loaded with mucus, or muco-pus, and the phosphates; it soon becomes ammoniacal after it has been passed, and there is a frequent desire to pass it. Electro-magnetic or Galvanic currents, I feel quite confident, are of very great utility in such cases, but must be used *perseveringly*. You may send a pretty strong current, frequently *reversed*, through the weak muscles, on the dorsum of the ilium, on the loins, thighs, and legs, for a few minutes every day; or the patient may wear one of the little portable batteries, (Humboldt battery,) with the poles fixed alternately on either limb, so as to keep up a constant mild current for a few hours each day or night.

There are recorded many cases by M. Lallemand, in his work on involuntary seminal emissions, in which the patients were feeble, or vacillating in their limbs, and afterwards became subjects of incomplete paralysis of the lower extremities. I do not question, for a moment, that paraplegia is a very common result of *frequent* seminal emissions, whether voluntary or involuntary. Indeed, it is undeniable that the *frequent* agitation of the ner-

vous system, particularly when so caused, does lead to chronic irritation, inflammation, and softening (or atrophy) of the spinal cord, with *paraplegia* as a necessary consequence.

*Spinal Exhaustion.* — I refer now to a form of paraplegia which comes on so insidiously that the sad victim of it, although young, or more likely along the very prime of life, is almost lost before he is aware that his health is seriously endangered. This disease is unaccompanied with pain, and it generally occurs in those gentlemen whose attention is so drawn from themselves, by active business or mental exertion, that they often pay no attention to the *earlier symptoms* — do not want to heed them, but rather strive to regard them as trivial and unimportant. Other cases of partial paraplegia, we know, are mostly inflammatory in their origin. The cases to which I now call attention are, I believe, *anæmic* from the first; they are, in fact and effect, cases of spinal exhaustion. You see the importance, then, of a correct diagnosis here, and as frank and open declaration of it to the patient.

The *history* of the person will assist you, if you start the right train of inquiry. Dr. Latham says, "*Prior* to diseases, to their diagnosis, their history, and their treatment, — prior to them, and back beyond them, — there lies a large field for medical observation. It is not enough to begin with the beginning of the symptoms. There are things and conditions earlier than the beginning of the malady, which deserve to be known. The *habits*, the necessities, the misfortunes, the very *vices* of men in society, contain materials for the inquiry, and for the systematic study of physicians, fuller, far fuller, of promise for the good of mankind than even pathology itself." The kind of inquiry here referred to and commended by Dr. Latham is, I believe, a part of, and an essential element of, true *scientific* pathology. With reference especially to diseases of the nervous system, its paramount importance is not — cannot be — too deeply impressed.

This class of nervous difficulty commences with slight numbness in one or both of the lower extremities. This is followed by some loss of power. There is no pain in the spinal region

at all. When you examine the spine, you may thump or press upon the processes and about them, from the neck to the coccyx, without producing pain. Still in some cases there is marked tenderness over the *cauda equina*, below the second lumbar vertebra. You find no evidence, says Dr. Lolly, in this connection, of "your patient having ever received any sort of injury to the spine. He cannot account for it at all. If, however, you ask him if he has had much sexual indulgence, he will say, *if he is frank, yes;* but more probably he will not tell. If, on the other hand, he says, indignantly, that he never had connection with a woman in his life, and yet shows these symptoms and history, it is almost certain that he is the victim of that dread delusion, masturbation."

The first thing to be done in these most important cases, is to *stop the error of habit* — the exciting cause. But this, from a long experience in this special practice, is found to be the most difficult part of our task. *Rest*, bodily, mental, and erotical, is the most important point in all the treatment. If your patient will not submit to rest, entire rest, absolute rest from all venery, and that for a long time, you had better take your leave without prescribing at all. I have known mercantile men, who were of business habits and sound sense in all other matters, also men of the professions, whose judgment is of the greatest value to their parishioners, clients, or patients, but who were such slaves to their venereal appetite and their own ideas of pleasure, that they would submit to any, ever so severe, plan of treatment that you like to propose, yet would not much abstain from such pleasures, or give up or even relax their ordinary but too close and ruinous mental application, or inordinate exercise.

The experiments of Dr. J. Reid plainly show that loss of contractile power in a paralyzed muscle is due, directly, to its imperfect nutrition, and only indirectly to the loss of connection with the nervous centres. When he divided the nerves of the hind legs of a living frog, and then left one limb inactive, but gave the muscles of the other frequent and regular exercise by

electrizing with the primary current the lower end of its nerve, he found (to state the case very briefly) that at the end of two months the exercised muscles retained their weight and texture, and their capacity of contraction, while the inactive ones (though their irritability, it might be said, had not been exhausted) had lost half their bulk, were degenerated in texture, and had lost some of their power of contracting. In other cases, too, he found the loss of proper texture always ensuing in the inactive state, before the power of contraction was lost. And it is doubtless the same in man. A muscle which, by no fault of its own, but through circumstances external to itself, has been prevented from acting, becomes shortly incapable of acting even when the external obstacles to action are removed. Hence, I think, we may deduce a rule which ought to be acted on in practice. When a person has had hemiplegia, one commonly sees that long after the brain has to all appearances recovered its power, or even through all the rest of life, the paralyzed limbs remain incapable of action — as motionless as at the first attack. Now, it is not likely that this abiding paralysis is invariably, nor even usually, the consequence of any continuing disease of the brain; rather we must ascribe it to the imperfect condition into which the muscles have fallen *during their inaction.* So long as the state of the brain makes voluntary action impossible, the muscles are suffering atrophy; then, when the brain recovers, they are not in a state to obey its impulse. They are degenerate; and thus, their inaction continuing, they degenerate more and more, and all remedy may become then impossible. If this be mostly true, Dr. Reid's experiments suggest a good part of the remedy. When muscles are paralyzed through affection of the nervous system, we ought to give them artificial exercise. They should often be put in action by electricity and otherwise, and that under repeated efforts of the guiding influence of the will. Their action, though thus artificial, will insure their nutrition; and then, when the nervous system also recovers, they may be in a condition ready to act with it.

### *Local Palsy.*

Paralysis of a muscle, or of a group of muscles, situated on the extremity, or on the body, is of every-day occurrence. This is caused by some one or more of a thousand circumstances that produce a lesion of the sentient nerves, or motor nerves; sometimes the cause can be traced, and sometimes it cannot. Lead poison, rheumatism, kidney affection, extreme cold or heat, prolonged *monotonous* labor, hysteria, concussion, wounds, &c., may often be the cause. A severed nerve will produce a simple palsy. A wounded nerve, in some instances, not only produces a palsy, but also *pain and progressive atrophy*. For these and other considerations, we will treat of "local palsies" separately under their respective heads. Nearly the whole of this tribe of affections are amenable to well-directed electrical treatments.

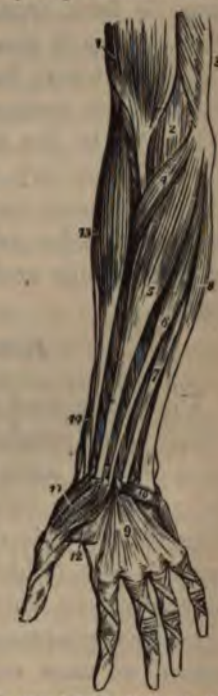


Fig. 130. A View of the Muscles on the Front of the Forearm, (Flexors.)

1. Lower Portion of the Biceps Flexor Cubiti.
2. Brachialis Internus.
3. Lower Internal Portion of the Triceps.
4. Pronator Radii Teres.
5. Flexor Carpi Radialis.
6. Palmaris Longus.
7. Part of the Flexor Sublimis Digitorum.
8. Flexor Carpi Ulnaris.
9. Palmar Fascia.
10. Palmaris Brevis Muscle.
11. Abductor Pollicis Manus.
12. Portion of the Flexor Brevis Pollicis Manus. The line crosses the Adductor Pollicis.
13. Supinator Longus.
14. Extensor Ossis Metacarpi Pollicis.

### *Anæsthesia.*

This is paralysis of sensation. It is precisely opposite to hyperæsthesia. In cases where the ordinary *want of feeling* is

simply from lost peripheral susceptibility to impressions, from nerve exhaustion, as by over-use or over-excitation, or if it is what is called functional, as, for instance, is often found in females about puberty, then electricity can act with its own peculiar potency and success. On the contrary, when the cause is from organic lesion, it is scarcely necessary to repeat, that no benefit can be expected from electricity, or any other means whatever; for anæsthesia may be caused by diseases of the nervous centres, nerve trunks, or of the sentient nerves. Whatever be the original lesion, that must be first subdued. Then, if we very sharply "Faradaize the skin" with strong electro-magnetic currents, using the wire brush or metallic balls as the electrodes, and applied close together, the sensibility will be most readily awakened and reëstablished. (See *Anæsthesiometer.*)

### *Facial Paralysis — Two Classes.*

Under the head of *isolated lesion of the nerves*, we have the simple *facial paralysis;* for of all the cerebral nerves, the *portio dura* or facial nerve is the one far more frequently attacked with palsy than any other. The first thing to be done here is to diagnosticate this simple affection of the facial branch of the seventh pair, (which is also called the portio dura,) from that other paralysis which in most respects resembles this, but which is rather a symptomatic disease of actual brain lesion. For this reason we must set out with the distinct understanding that *there are two very different kinds of facial palsy;* the one arising from a *sudden* cooling, and hence neuralgic, or from the severe local or protracted exposure to cold, and hence rheumatic; or it is due to pressure somewhere along the bony exit of this nerve trunk, after its exit from the cranial cavity, as from a tumor or exostosis of bone, or from a syphilitic or scirrhous deposit in its sheath; or it may arise from a neighboring bony caries and consequent suppuration; the other form — the symptomatic and grave kind — arises from an intra-cranial origin.

Now, we will observe, first, in regard to this latter type of the disease, which arises from a brain origin, or from some injury to the intra-cranial portion of the seventh nerve, that we usually

get some characteristic difference in the symptoms, as a loss of taste, with a numb sensation in the side of the tongue, caused by some intercepting influence that cuts off the physiological function of those nerve fibrils which come from the *chorda tympani;* there is also a difficulty of deglutition from paralysis of the *digastricus* and *stylo-hyoideus;* the hearing is affected, and the uvulva hangs towards the sound side; and in some cases, although the patient can move the tongue, yet there is not the ability of *covering* the upper lip with it, so that its tip shall reach the septum of the nose. Wherever the tongue and the pharynx are involved in the paralytic affection, it should put us on our guard, as being indicative of some mischief in the brain. But the most distinctive characteristic difference between the two kinds of facial paralysis is, that *a paralysis of the orbicularis palpebrum does not occur in a facial hemiplegia of a central origin.* Therefore, *if the eye cannot be shut,* we may rest assured that the case is one of simple paralysis of the facial nerve, and is suitable for treatment. It is worthy of notice, that the grave symptoms of a lost taste, difficult deglutition, and deviation of the palate *may possibly arise from poor dentistry plate work,* such as is sometimes worn as temporary. The author has seen several such instances, and some of them very serious indeed, being of long standing. But it should be known that these are generally amenable to the so-called localized use of electro-magnetism. But let us notice what further *is not* the simple paralysis of the *portio dura* or facial nerve.

1. If the *motor oculi,* or third nerve, be paralyzed, as it divides into two branches and enters the orbit between the two heads of the external rectus muscle, the superior branch ascends and supplies the *superior rectus* and *levator palpebræ* muscles, the eyelid, particularly the outer angle, cannot consequently be raised, from loss of power in these two muscles; and this constitutes *ptosis.* There is also in such a case a protrusion of the eyeball, which cannot be turned inward, and at the same time the outward lateral movement of the eyeball is not impaired, since the *rectus externus* is supplied by the sixth nerve; there are also a marked dilatation of the pupil, double vision, and only a *distant*

sight, i. e., it is next to impossible for the patient to adjust the eyes to see objects close by.

2. If there is a paralysis of the fourth nerve, (*pathetici*,) the symptoms are but slight. The patient experiences some double vision, when looking on a level; and to avoid it, the face is carried rather to one side, and that the sound side. When looking upward, the sight is not much disturbed, because the affected pupil is turned a little upward and outward.

3. If the *abducentes* (sixth nerve) be paralyzed, then the patient has "*converging strabismus*," or inward squint, and is also troubled with a double vision when looking in certain directions, and this in proportion to the extent of the affection. If it occurs in connection with the paralysis of the third nerve, as indeed it often does, then the eyeball is immovably fixed, it being drawn forcibly towards the nose, so as to cover the whole cornea at the inner angle of the eye.

These three paralytic affections of the eye *may* arise from brain origin, but not necessarily so. There may be pressure on the trunk of either of those nerves that are affected; but the trouble is supposed to arise more frequently from a rheumatic or syphilitic exudation on the sheath of the nerve, or from an over use, or very deficient use, of the eye muscles. For these cases, where not positively contra-indicated, I am in the habit of employing either Faradaic or Galvanic currents directed locally to the muscles involved, for two or three minutes, always closing the *seance* by "*washing*" the whole face and neck with just bearable induction currents, and that by ceaseless *labile* movements, for one or two minutes more, using large, soft, wet sponge electrodes. The tip of the finger of the operator, or the two small sponge-tipped ivory electrodes, are best for conveying the current to the affected muscles. Dr. Meyer, of Berlin,* has recently treated some of these cases successfully, by electricity. He placed the negative pole of electro-magnetism in the hand of the patient, and then employed a very small, moistened sponge as the *positive* electrode, which he applied directly to the skin of the closed eye, as near as he could to the paralyzed muscles. For reaching the *rectus internus* he held this electrode to the

* Deutsche Klinik, 1856, No. 38.

inner angle of the eye; and for the muscle *obliquus superior*, he placed it beneath the *trochlea*. He thus treated, it appears, a patient for Dr. Von Graefe, who had been afflicted for five months with double vision, from a paralysis of the *rectus internus* and *obliquus superior*. Dr. Meyer treated another case that had suffered for some four years with double vision from paralyzed muscles of the eye, in whom he effected a complete cure in six weeks, by electricity. The author would recommend great care in attempting to employ Galvanic or Faradaic currents about the eye. It is probably more wise and prudent to employ first the *labile* induction current in all these cases, and that moderately; but still do I know that the former can succeed, where the latter may fail.

### *Paralysis of the Facial Nerve, (Portio Dura.)*

There are, then, *two kinds of facial* palsy. The one kind we have just been examining and treating. But the true and simple paralysis of the portio dura, in whole or in part, but outside of the cranial cavity, and hence most suitable for electric treatment, is characterized and known on the one hand by *the want of power over the eyelids*, so that the eye cannot shut by the action of its own muscles; and on the other, *as not* attended with loss of taste, nor is there numbness in the tongue, nor difficulty of swallowing bread. When this face affection comes on from exposure to a draught of cold air, as from a car window, it is then more generally of a rheumatic character; and hence some of the muscles are affected more than others; and some of them also recover sooner than others. The absorption of the rheumatic effusion is sometimes spontaneous, at least to a degree. In all these cases the electric currents are found to be decidedly the most effectual means for restoring the muscles to their healthy state and physiological action. If the facial paralysis is complete, then all the expressions of the physiognomy flat out; i. e., on the paralyzed side, but are exaggerated on the sound side. But if both sides of the face should be similarly affected, then the countenance of the individual is totally changed. Nor is he able to laugh, frown, or whistle—or only on one side, if but the

other is affected. In that case, the palsied side appears bloated, pouting, and drawn around towards the sound side. But as this nerve is the motor for nearly all the muscles of the face, let us examine the effects of its partial palsy.

Where there is a paralysis of the muscle *orbicularis palpebrarum*, which is depending on the *portio dura*, as we have said, the eye cannot be closed; the eyeball is all the time exposed to the air, even during sleep, and consequently the conjunctiva is liable to become injected or inflamed. In that case the tears flow freely over the cheek, and sometimes so acrid are they that they excoriate the skin of the face. The eyelids are kept open, because the antagonizing muscle (*levator palpebræ superioris*) *is not* depending upon the *portio dura*, but is animated by the third nerve. On the contrary, where the third nerve is palsied, the eye is *shut*, and cannot open of itself. But in facial palsy, when the patient is requested to shut the eye, if any motion is perceptible at all, the ball of the eye is only turned upward and inward, but the eye does not readily or completely close. The eye appears staring and somewhat protruded, showing considerable of the *sclerotica*, which is mostly due to the dropping of the outer portion of the under eyelid; but there is no such evidence of *deficient nutrition in the cornea and conjunctiva*, as observed in cases where branches of the fifth (tri-facial) nerve are paralyzed; and if the fifth nerve be the one paralyzed, then there is *anæsthesia also* of the face, and that perhaps *without* the loss of motion, because the fifth is mostly a nerve of sensation.

Again, if the *corrugator supercilii* muscle, and the anterior portion of the broad *occipito-frontalis* muscle are paralyzed, — for they are depending on the portio dura, — then the forehead is smooth — and cannot be wrinkled; nor can the patient frown. The transverse wrinkles depend upon the first-named muscle, while the perpendicular wrinkles, as seen between the eyes and over the nose, depend upon the *corrugator*. In extreme cases of such paralysis, the eyebrow drops so as to hang over the eyeball, and give the countenance a most doleful appearance.

If the twin *zygomatici* muscles, together with the *levator anguli oris* are paralyzed, as they too are animated by the

portio dura, then that angle of the mouth is greatly depressed, and the whole mouth is drawn to the opposite side; but on the sound side the corner of the mouth appears to be higher, and drawn upward towards the ear. On the palsied side the corner of the mouth gives the fullest expression of pouting.

If, then, the muscle *orbicularis oris* is paralyzed, it is shown by the patient being unable to purse up the mouth, or to whistle; the lips are drawn and stretched by their sound end far back towards the ear on the sound side, allowing a drooling of the saliva, and greatly preventing labial pronunciation.

If the deeper and larger *buccinator* muscle be paralyzed,—for this, too, is depending upon the portio dura,—then that cheek will appear remarkably bloated, flaccid, and old. And during respiration the cheek is then seen to be unable to resist the outward and inward pressure of air, and hence the breathing is sometimes *stertorous* in some degree, much as it is in apoplexy when this condition obtains on both sides during the fit. The power of biting is not much impaired, for the very good reason that the *masseter* and *temporal* muscles are not depending upon the *portio dura* nerve; but the process of eating is awkward and troublesome, because the food accumulates between the cheek, the teeth, and gums.

And again, if the *levator alæ nasi* and the *pyramidalis* are paralyzed, then the nostril on that side is deprived of voluntary motion, and the nostril is retained open only by the elastic fibre of its structure. Hence the gentle waving motions in the sides of the nose during respiration are lost, or *exactly reversed;* i. e., in health the nostrils are dilated during inspiration, but in facial palsy this is noticed as occurring during expiration. In the horse this would be a fatal affair if it occurred on both sides, as his nostrils are very soft, and kept dilated by the action of the *portio dura.* When this nerve is severed in the horse, his nostril flaps together, and the more violent the inspiration, the greater the collapse of the nostril. As the horse breathes only through his nose, he must die of asphyxia if the facial nerve is either severed or paralyzed. So also, if the *portio dura* is severed in the ass or rabbit, the ears

drop and become hideously deformed, because they are soft and long; but no such abnormal symptoms show themselves in man from an actual paralysis of those branches of the *portio dura*, that in the human organism also ramify the external muscles of the ear, because the human ear is kept in its normal position by its partial structure of elastic fibre. And this completes the list of the prominent symptoms of facial paralysis, which may be seen occurring either together or separately, being caused by *a palsy of the superficial branches* of the *portio dura* or facial nerve.

To recapitulate: if the *trunk* of the *portio dura* is injured in its *intra-cranial portion*, then we do not see the above *isolated* symptoms, but, they would then be general and uniform; and not only so, but as we have seen, there are collateral symptoms from the eighth nerve, as it also is involved; there are loss of taste, and a sense of numbness in the tongue, caused by palsy of the *corda tympani*. There is also difficulty in swallowing, from the paralysis of the *digastricus* and *stylo-hyoideus* muscles; the uvula is drawn to the sound side, and the tongue *protrudes to the sound side and downward;* and the hearing will be affected, and perhaps attended with very peculiar noises in the head.

The *deep-seated* palsying effects on this great nerve trunk may arise from otitis, caries, and necrosis of the petrous portion of the temporal bone, or from sanguinary congestion, or inflammation of the nerve sheath, &c., and this may sooner or later extend to the brain, according to the nature of the solution of continuity. Some such results we see soon followed by more grave symptoms, or even death. Other rare cases, after a time, appear to be attended with an irritative inter-cranial cicatrix, and hence there sets in a rigid and permanent contraction of some of the muscles of the face. It is obvious that any electrical treatment here is both useless and hazardous. But in others it happens that after this grave paralysis has continued for a considerable time, the whole set of affected muscles take on a shade of improvement. And here we may find now and then a person we can save, by bringing electricity as a timely aid, if employed prudently, but perseveringly, and that with other rational treatment. There is the best of testimony

that such recoveries are not rare, even after a half dozen or dozen years' standing.

Dr. Duchenne lays down the *rule* that whenever the paralyzed muscles of the face, which give a pouty cast to the features, also respond "*very sensitively*" to electro-excitement, by such prompt contractions as show that their excitability remains intact or is exalted, it is evident, according to this experience, that the facial hemiplegia is due to a true cerebral source. But if the muscle *orbicularis* of the eyelid is paralyzed, and on the other hand if the muscles *do not* so respond to the electric excitement, we may then be quite certain that the facial hemiplegia cannot be referred to a brain origin and source. In this latter case the affection arises from a pathological *state* of the facial portion of the seventh, or *portio dura*, nerve. He speaks of having repeatedly cured cases of paralysis of the tongue and face by the means of Faradaic currents.

As regards the number and length of the treatments *for such cases as where we are not quite certain* as to their nature or state, it is thought most wise not to make the *seance* so long or so thorough; and if not restored, after some ten to fifteen treatments, it had better be omitted; and after some delay, it can be again repeated.

### *Hysterical (Reflex) Paralysis.*

*Hysterical palsy* occurs only in well-marked hysterical women and men, and under circumstances that develop this state and result. I believe that it is produced by a too profound disturbance of the great nerve centres, or by a reflex action affecting them. There is, however, no discoverable disease that is structural, either of the brain, of the spinal cord, or of the ganglionic centres, so far as the microscope can discover. Still, the suddenness and apparent gravity of this kind of palsy, when it shows the paraplegic or hemiplegic form, seems to point to organic disease for origin. It most frequently resembles rheumatic palsy, or hemiplegia; and may be mistaken for many other forms of paralysis; or, indeed, it may be complicated with any one of them. We may recognize it, usually, from the fact that it

appears only in a certain class of persons, after the influence of some powerful emotion, or from a reflex cause that is discoverable; from the absence of any other signs of nerve lesion; by the incomplete character of the palsy, and the fact that the muscles of the face and tongue are *not* involved; from the sudden appearance, and sometimes just as sudden partial, or complete, disappearance of it; and the possibility of the patient being able, under sudden great excitement, to move the affected limbs. The electro-muscular *contractility* is still intact in recent cases, while the electro-*muscular sensibility* is greatly diminished, or abolished; this latter — in true cerebral palsy, we know, is unchanged — such are the characteristics of a purely hysterical palsy; but it is frequently complicated.

*For treatment*, these cases must be viewed in two classes. The first is where there is considerable *anæsthesia*, for which we are to apply a very strong and smart current, either through two large sponge electrodes, in double part-circle movements about each other, over the delinquent muscles, to electrify them to contractions; or by placing one large sponge electrode (positive) to rest at the spine, or root, or exit of the supplying nerve-trunk, while the other is the wire brush, or a metallic ball-tip, or a wet buckskin electrode for faradaization. The electricity should be perfectly intense, and the direction of the current should be suddenly changed every half minute, so as to not only redden the skin, but to move the muscles, and alter the polarity of the nerve-cords. Doubtless, in this class of affections, it is in part due to this strong impression, effecting a profound reflex action on the nerve-centres, that a cure is brought about.

The second class for treatment are those with more or less *hyperæsthesia*, and a great excitability in the patient. Here we must usually begin by applying a down-running and moderate primary, extra, or faradaic current, only through large, soft sponge electrodes, and without increasing the current, or once reversing the current direction. One electrode should be planted at the nucha, or coccyx, while the other is gently glided over the paralyzed part. Indeed, for some, in the first few sittings, we are to employ almost no current, doing little more than gaining the confidence of the patient for the manipulations,

and then very gradually increasing the quantity or intensity, all the while bearing in mind that this little effects more here than ten times as much in other cases.

*Hysterical Paraplegia.* — Fannie H., aged twenty-four; fleshy, but nervous, and subject to occasional fits about the time of her periods. Otherwise she was represented as having been in good health until a few days before I saw her. She having been exposed to a cold north-east rain-storm, but notwithstanding umbrella and waterproof, had got wet and quite chilled. The next day she felt a chilliness down her back and a sense of numbness in her legs, which increased rapidly day by day until she could not walk. I found sensation on all parts of her body normal, except below her knees, where it was totally wanting. There was complete loss of power to move either leg; but on tickling the sole of either foot, a very slight reflex action was seen. The feet were clammy and cold, and she said the legs were inclined at times to jerk up of themselves. A part of the time she was unable to retain her water, and she complained of some pain and soreness in the dorsal region. She was directed to take a laxative composed of equal parts of tr. rhei aromat. and elix. pro., and to repeat a half dose every morning after, and to be put upon quinine and iron, with one thirtieth of a grain of strychnia, three times a day. I also ordered the legs and the back to be smartly faradaized through moist sponge electrode, in slow double-circle movements, for ten or fifteen minutes daily. She gradually improved from the first week, so that in six or seven weeks she had entirely recovered. Has been perfectly well since.

*Thrombosis simulating Hysterical Knee-joint with Paralysis.* — Mrs. M., twenty years of age; plump in form and dark complexion, with a naturally nervous temperament; could eat well, but while sleeping had horrid dreams of late; and though evidently of a delicate organization, was not liable to be sick. Had been married about seven weeks, but no menses since. She was brought to me by her mother, from an adjoining town, by the advice of her medical attendant, for the purpose of receiving galvanic treatment for what was supposed to be an hysterical or

a rheumatic affection, or both. I was entirely thrown off my guard by the superficial examination, in consequence of the extreme modesty of the patient, refusing to have the limbs seen, or scarcely touched; and falling in with the previous opinion, I proceeded at once to make the application of electro-magnetism as localized faradaization, through soft, wet-sponge electrodes; directed, at first, to the ankle, and gliding them along up over the anterior tibial muscles. Using a smart current, I guided them along some three inches of each other, while constantly bathing the limb below the knee, and through the knee, also on the upper and outer sides of the thigh. This caused her no pain, not even the ordinary sensation of prickling; and yet there was some tactile sensibility. I found the limb of the natural warmth and not swollen; but she said it had been swollen, and was exquisitely tender to the touch; all of which was too readily ascribed to the hysterical character of the affection. This patient was of remarkable beauty, culture, and vivacity. Notwithstanding her painful and helpless condition, she made fine jokes on her own case, and said nothing ailed her except a stiff and "*sensible*" knee, with an "*insensible*" and paralyzed foot, which were well enough when let alone, and while she was perfectly quiet. But she showed the greatest trepidation while any motion was being made towards the limb, or even to point at any portion of it. No cause could be ascribed, as the affection had come on gradually, since her husband, a young officer in the United States service, had left for the field some two weeks previous. She remarked to me that the whole limb felt very sore, at the same time passing her hand from the calf of the leg upwards over the knee and inwardly over the adductors, perhaps to the groin. By passing my hand under the limb, as she was sitting, the hamstrings were found tense and the limb held stiff at a slight angle. Thus finished the first *seance*, and she was advised to call in a day or two and have it repeated. She did so, but the limb was no better. She was to have called the third time, but the limb became more painful, and Dr. Miller, of Dorchester, was sent for to see her at her house, in her bed. He diagnosed the true state of the case, namely, inflammation of the femoral veins: their *com-*

*pression of the crural nerves* produced the paralysis, pain, and stiffness; and this also accounted for the swelling and tenderness. She kept quiet in bed, with compression and cold applications nicely adjusted to the limb, and she gradually though slowly recovered.

Here was one of those rare cases in which the blood coagulates in the veins of the leg after pregnancy, yet without giving rise to all that train of symptoms which usually constitute actual *phlegmasia dolens*. The application of cold to the limb, perfect rest of body and mind, and the generous use of diffusible stimulants, (without iron) are the principal indications, until the inflammation is entirely subdued; then, if paralysis or muscular stiffness and soreness remain, faradaization and deep-shampooing, with passive and then active movements, will aid to the perfect recovery.

A true hysterical paralysis is seldom seen without other marked symptoms of hysteria, either present or past, as globus, cramps, pains, or some uterine disturbance; but in other respects, this paralysis *very nearly resembles* those cases that are caused by disease of the brain or spinal cord, or those of rheumatic palsy. This affection is more usually found to involve the muscles of the arm and leg on the same side; if both, then it is termed *hysterical hemiplegia*. If it be seated in the *recti* muscles of the thighs, or other muscles of the legs, (for it is more likely to attack but one limb,) then it is called *hysterical paraplegia*. If it be local, and affecting only a single muscle or muscle group, then it is termed *local hysterical palsy*. If it be local in a joint, then it is termed an *hysterical joint*. But in *this kind* of paralysis there is no sort of disease of the motor nerves, nor yet of the nervous centres. It may gradually appear, or it may attack suddenly, as from fright, great excitement, intense anxiety, or profound grief.

According to Dr. Duchenne, we should find the test of electro-muscular contractility in all cases of hysterical palsy, at the normal state, i. e., as in health; but that the "*muscular consciousness*" is nearly or entirely gone. Now, this is not found to be true in the great majority of cases of some standing, who apply for treatments, while *it is quite true of some of the more*

*recent cases.* The greater number of cases who call for aid are of long standing, and these, certainly, show a marked diminution of susceptibility to the electro-muscular contractions. And another thing I can say, speaking from experience, and that is, that nearly every case of hysterical paralysis, no matter how bad or how old the case, can be cured by well-directed electro-therapeutics, aided by any other needed rational medication and regimen.

I know it is true that some cases of "hysterical palsy" and "hysterical joints" are little more than mere *fantasy*, and are kept up in a great measure, as Dr. Rowland says, "by the patient lending herself to the task, and refusing to exercise her command over the refractory muscles or joint." A rough *shock*, or *a strong moral impression*, or rather "*occupation that continually interests*," may at once remove the disorder in some such cases; but it is exceedingly doubtful in my mind whether any such means could be productive of benefit, in many other cases. Hysterical paraplegia may *commence* from irritation of the uterine nerves. There is a form of this affection that is always accompanied by some kind of derangement in the function of the womb, or bowels, or both, and is as totally unallied with organic change, or any action conducting towards such change, either in the brain or spinal marrow. The attending "pain in the back" is that commonly known as *spinal irritation*. It varies from day to day, sometimes being very severe, at others almost null, while perhaps slight pinching up of the integuments that cover the spine is as productive of actual pain and suffering as firm pressure could produce. The lower extremities are rather colder than natural, and *there is an entire absence of ordinary* sensation in them; and when the limb or limbs are strongly flexed, there is severe pain. There is pain also from slight pressure in the lower dorsal region, or over the sacrum. The appetite is wrong; the bowels are slow; the sleep is wanting, or is disturbed; and the urine, upon test, is found loaded with lithates. Such it is.

Case. — Mrs. C., of Brookline, twenty-seven years of age, had been troubled with a partial paralysis of the right lower limb for some five years. Sometimes it would be better, and then again

there would be months together when the limb would be so paralyzed that she could scarcely get about the house. She had been long under the treatment of one of our oldest and best physicians, who also believed her to have been an exquisitely hysterical girl. Since her marriage she made the tour of Europe, spending a season in Italy and Switzerland, where she became quite well. She could climb mountains, the long stairways of palaces and towers, and even the pyramids. But she was no more than home again, than she was as lame (i. e., as paralyzed) as at her worst. This condition was not now intermitting, or in any sense remitting, for her limb remained in this state during the summer and fall, until she came to me for electrical treatment. She could scarcely walk when assisted; but there was one very noticeable feature, for while her walking was slow, hesitating, and extremely irregular, there was a dragging of the palsied limb after her, as if a piece of inanimate matter. This indeed is pointed out by Dr. Todd as the very *diagnostic sign* between hysterical paralysis and all other lower-limb paralyses arising from other causes. In fact, the limb appears to be merely drawn straight along by such a patient, just as if inanimate, or as an artificial limb, while the foot swings to the one side, nor is she able to straighten it.

Upon applying the electro-magnetic *test*, I found that the *rectus* of the thigh did not at first respond in the least to the half-strength current; but if the electrodes were then similarly placed upon the sound other limb, response was there prompt and complete. Thus was this by history and test, fairly diagnosticated as a case of hysterical paralysis, and as such was treated by suddenly *alternated* primary and secondary currents of electricity. The electrodes were always placed, the one over the nerve trunk, say at the right abdominal ring, or at the anterior crest of the ilium, or just under Poupart's ligament, while the other electrode was being swept along the border points of the affected muscles, and at the same time using a strong Faradaic current that was suddenly reversed, say every fifteen seconds, by the current changer of the key-board. The sittings continued never over fifteen minutes, and were repeated every other day for one month. The cure was complete.

*Hysterical paralysis of the bladder* is not uncommon, and it should be recognized, so as to receive the general and constitutional treatment and regimen, as clearly and as thoroughly as the local. Sir Benjamin Brodie indeed lays down the *rule*, that the catheter should not be resorted to in these cases, *only in those extreme exceptions* where the paralysis is actual. A similar want of power over the *rectum* sometimes occurs in this *state* of the nervous system. Now, in most of these cases, it is not so much the fact that the muscles are incapable of obeying the orders of volition, but rather that *the function of "volition" is suspended.* Therefore, if electric currents are applied to the spine to re-establish this function, it affords the cure. (See pp. 466–470.)

*Hysterical Affections of Joints.* — Sir Benjamin Brodie states the remarkable fact, which no one is so well able correctly to ascertain as a surgeon of his great experience, that four fifths of the supposed cases of *joint diseases* which occur among the better classes are truly hysterical. You may always expect to find in these cases other indications of the hysterical state. See his practical little volume on "Local Nervous Affections." He says there is always exceeding tenderness. The joints most frequently affected are the hip and the knee. The patient keeps the painful joint quite at rest, and always yielding to a partial flexed position, and being fearful of the least disturbance. When the joint is moved by you, she will call out with much more expression of pain than if there were actual ulcerative disease of the cartilages.

Dr. Balman, of Liverpool, gives an interesting account of a case of *hysterical paralysis* in a young lady of seventeen, that had been treated for three years for curvature of the spine. The curvature at first appeared to be lateral, but subsequently angular curvature came on. When he first saw her, she was upon the sofa, looking pale, but otherwise appearing well. Her attendant said she had been unable to stand, walk, or speak, since the fit of the previous day. "Upon examination," he says, "I found the spine very crooked, with an angular curvature of the last two dorsal vertebræ; on passing my fingers down the median line, there appeared to be distinct tenderness both between the scapulæ and over and about the seat of the projecting spine, extend-

ing down to the sacrum; the feet and limbs were cold, livid, and completely insensible to the prick of a needle, as far as the knees; the hands were in a similar condition, but the loss of sensation did not extend beyond the wrists.

"Although unable to stand or support the body for a moment without assistance, I soon afterwards learned she was enabled to turn the feet about in almost any direction when lying down in bed; her nights were restless and without sleep, and the eyes presented that peculiar glistening aspect so characteristic of hysteria. She complained of headache, and cramps over the whole body; these were rendered very distressing by cold, and pressure of every kind; even a very powerful liniment served but to renew the cramps, and destroy all sense of feeling on being applied to any part of the body. I very soon had an opportunity of seeing her in one of the paroxysms, which now generally occurred about once in twenty-four hours; these, as in similar cases of this mysterious disease, were truly frightful to witness; the limbs were extended and rigid as marble; hands clinched and immovable; the head and neck thrown back; whilst the whole body appeared to be convulsed and writhing under the most violent tetanic spasms. Sometimes the symptoms for a time assumed a different character, and she would lie motionless in one position for hours together, in a state more resembling catalepsy than any thing else.

"I commenced the treatment with the usual routine of antispasmodic and tonic medicines, such as ammonia, iron, fetid gums, &c., without much apparent benefit; opium was administered at night, to soothe the irritability of the nervous system and induce sleep, but without success; three grains of solid opium, given at bed time, served only to make her still more restless, without any narcotic effect being produced whatever.

"September 6. — After one month's trial of these, and a variety of other remedies, finding matters but little improved, the pain in the lower part of the back being constant, and the severity of which I was inclined to think contributed in a great measure to renew the fits, whilst the paralysis, if it may be so called, remained stationary, I began to think that there must be some irritation of the spinal cord or its membranes. I now, there-

fore, applied seven or eight cupping glasses along the whole of the spine, *every alternate day;* prescribed small doses of the hyd. c. creta and carb. of soda every night, and a turpentine enema every third morning. On one occasion I ventured to apply the scarificator, and took about three ounces of blood, with evident relief. Under this mode of treatment she began steadily to improve; headache much relieved, and the pain and tenderness of the back not so urgent; she also soon passed better nights, sleeping three or four hours together soundly; the attacks returned on two or three occasions afterwards, always just before the approach of the catamenia. The lower extremities, however, continued useless, and without any return of sensibility, and she had, as usual, to be carried by her attendant from room to room. I now commenced to apply galvanism, with a view of restoring the use of her limbs. At first the shock of a very powerful battery was not felt on placing one pole to the sacrum and the opposite one to any part of the leg below the knee; but after a few trials I found one isolated spot, about the circumference of a shilling, over the outer part of the tibia, a few inches below the knee, sensitive to its effects. Continuing its use every day, the feeling seemed to radiate day by day downward, over the whole of the external part of the leg to the ankle, the inner part of the leg remaining, as before, completely unaffected by the electric current; the sensibility, however, soon returned here likewise, and extended gradually to the extremity of the second toe. Immediately after the next *seance*, I learned with satisfaction, that soon after my leaving the room, my patient got up very coolly and walked across the room, and indeed over the whole house, unattended or supported by any one. This happened on the 12th October, since which she has continued to take regular walks out of doors for considerable distances, and is rapidly improving in all other respects."

As regards the actual seat of this disease, it in all probability was connected with some congested state of the *spinal veins;* and, indeed, it does not seem very difficult to imagine why this state of things should occur, if we carefully examine the anatomical arrangement and structure of the venous system of

the spinal cord. Thus, according to Breschet, there is every thing here calculated to favor stagnation of the blood.

1. The veins are deprived of valves, thinner, and much more delicate than in any other part of the body.

2. They are relatively very numerous, subdivided, and tortuous; so that each spinal nerve may be said to be literally encircled and bathed in venous blood, as they penetrate in the intervertebral foramina.

The consequence of this arrangement, notwithstanding the frequent communications by which this impediment is in some degree obviated, must be, that the blood will move more slowly, and with greater difficulty. That congestion does sometimes happen from this peculiar disposition of the veins of the spinal axis, must, therefore, be extremely probable. Olivier mentions that he had often found in his dissections fibrinous clots blocking up and distending the veins of the spinal cord, and even those which accompany its nerves; and many other instances are related by Morgagni.

The influence of electro-magnetism in restoring the power of locomotion is here certainly more remarkable than any thing ordinarily witnessed. That this was in reality the result of the electric stimulus, and not, as we know is sometimes the case, by some sudden moral impression unloosing the magic web, which seems to hold captive the power of volition, I think there cannot be the least doubt. The effect of this agent was perceptible at each application; for it was not until the remedy had been persevered in for some time, that the beneficial results were manifested so strikingly.

"To show how powerful electricity can stimulate the voluntary muscles," says Dr. B., "I may add that she felt, as she often expressed, a strong inclination to walk after each *seance*, — so much so that she many times made the attempt, but always without success, — falling thump upon the floor, until the period mentioned; and even then, when she had regained the power of standing in the erect attitude, it required much determination to keep it; and but for the exercise of a series of movements, she feels convinced that she would not have been able to retain her position.

"I may mention that I have made trial of this remedy at a much earlier period in this case without observing any benefit; on the contrary, many of the symptoms appeared to be aggravated, after its use. It was, therefore, at a particular stage of the disease, when counter-irritant and alterative medicines had removed the more active symptoms of the complaint, that galvanism appeared to do good. This remedy, therefore, like any other, is applicable *only under certain conditions;* and the success of it will depend not only upon the tact and acumen of the practitioner in the selection of his cases, but also the particular phase of the disease at which its use is apparently indicated."

There is a singular case mentioned of a young girl aged seventeen years, that must be rare, but it is quoted here to show the rallying power of electricity in some desperate cases. This case, by the way, was witnessed by MM. Coindet and Duval, in Geneva. It seems that, under an hysterical influence, there suddenly appeared on the hand of the young lady a "gangrene," the result of a temporary stoppage of the circulation in that limb. All the fingers of her right hand became of slaty color, cold, and anæsthetic, and the patient suffered at the same time most acute pains; the radial pulse was totally gone. Here — i. e., in this stage, after all other means failed — electricity, after Dr. Duchenne's method, was hastily adopted, and after only ten minutes, the girl cried out that she was able to move her fingers, and she did move them; the pains, that had been agonizing, ceased; the radial pulse reappeared; sleep, which had been wanting for five nights, was at once enjoyed; but upon waking, the pains returned. After each *seance* the pains were calmed, stiffness of the fingers was less firm, the night's rest became good; the rigidity of the arm soon disappeared after the first *seance*, and the throbbing of the arteries was established as natural. What was very remarkable, from the second day, there was produced, after each treatment, a profuse transpiration from the fingers of a very fetid odor. In seven days, the color and warmth of the hands were mostly restored, although her general health was evidently broken and poor. We see, however, that the local good effects of the currents were incontestably evident.

### *Aphonia, or Loss of Voice.*

In every new case of aphonia, we must be on the lookout for chronic laryngitis, for syphilitic growths, for tuberculosis, ulcerations, tumors, and aneurism of the aorta. When the laryngeal nerve is irritated or compressed, by tumor or otherwise, we get irritation, weakness, or paralysis, manifested in altered voice, in partial or complete aphonia, and perhaps impaired respiratory movements of the glottis, or spasm of the glottis with difficult breathing and aphonia. Of course, in such cases, in this stage at least, electricity can be of no sort of use. The cases of aphonia that we propose to cure by electricity are *nervous aphonia* — the atonic, the rheumatic, and hysteric cases — simple uncomplicated *palsy* of the *cordæ vocales*. We recognize a laryngeal paralysis, complicated with organic disease, that resists all remedies.

Nervous aphonia is not always so readily diagnosed. But generally, if uncomplicated, we know it when it comes on suddenly; there is absence of cough; no expectoration, no local pain, no trouble in breathing. The history may aid us, for we know it is produced by strong emotional suffering; overstraining the voice, as in singing or speaking; it may attend anæmia, or follow a cold, and be more rheumatic; or it may be the result of taking narcotics; but, probably, more frequently it is the result of a reflex action, due to gastric irritation, or disorder of the uterine system; or to a morbid or deficient power in the solar plexus of nerves. As evidence of this character, we may often find the voice suddenly disappear, and as suddenly reappear, and again as suddenly disappear probably, if unaided.

Keeping in mind this character of the affection, I am in the practice of making *daily* sittings for these cases; one day directing the electricity to the throat, inside and out; the next day thoroughly electrifying and faradaizing over the region of the diaphragm, the vital organs, and the solar plexus. If the case is anæmic, there is required a preparation of the system by iron and tonics, or there is to be a simultaneous use of them; if rheumatic, the patient must be put upon iodide of potassium, or

congress water. Then, for the seance for the throat, take a large sponge electrode in each hand, and first electrify the neck and throat surface for a minute or so; then, placing the positive sponge under the chin, take into the right hand the laryngeal electrode, number 102, with the spring open. Tell the patient to fill his lungs, and hold his breath for a second or two, and then to say *ah*, slowly; when you are to glide the electrode to the seat of palsy, press the spring, (at quarter or more battery power,) telling the patient to hold his breath, and bear it as long as he can, even to a minute if possible. Do not tax him too long, but first raise the spring and so stop the current, then carefully bring this electrode out of the throat for a little rest. Repeat it thus two or three times. The next day place him reclining on his back; and with spoon-sponge electrodes first electrify the muscles by double-circle movements; then, planting the positive over the umbilicus, move the negative, with a strong current, about the waist, and so over the thorax and throat, making the pectoral muscles contract, also awaking the diaphragm. If this is pursued for a week, and fails, apply a large blister about the waist; when it heals, repeat the electricity.

*Organic aphonia* was found in a case that came to me for electric treatment. A young lady of twenty-two first had a hoarseness, of more than a year's duration; which was followed first by partial, then complete aphonia, which had lasted for over five years, in spite of the best advice and treatments that could be obtained, — all of which throat affection had been ascribed to an hysterical state. But on inspection of the throat with the reflected light, it was found that the difficulty arose from several simple growths on the true and false vocal cords of the right side, and involving the whole length of the cords, but more at the arytenoid cartilage. Local applications of solid nitrate of silver, aided, or rather followed by repeated applications, internal and external, of faradaic electricity, restored the voice, and cured the follicular deposit completely in some five months. That the disease was utterly eradicated, and the voice actually restored, is proved by nearly four years' recovery without a sign of tendency to relapse.

Nervous aphonia is generally not attended with a cough; but

I had such a case from Dorchester, in a young lady of eighteen, that was very marked. She had a very peculiar, deep, lazy cough, that was not only sepulchral, but almost incessant, day and night. She was fairly worn down with it, after coughing so many months, as were all who were obliged to hear her. She was cured by electricity, applied as I have directed; has remained well, and is now married some two or three years.

Dr. Grapengeiesser, a German physician, cured a case of aphonia by means of voltaic electricity, as long ago as 1801. He drew a blister on each side of the throat, as had been recommended by Baron Humboldt. After removing the raised cuticle, he applied to one of these sores a small plate of silver, and to the other a small plate of zinc. These two plates, being first bound on the sides of the larynx of the patient, were then brought into metallic contact by means of the two connecting wires, which were brought together and twisted. This was borne but for a quarter of an hour. The larynx began to heave convulsively, and there appeared also an abundant flow of ichorous fluid from the raw surfaces, and a sighing or sobbing continued for some time. There was soon observed a free expectoration of mucus, which was followed, in the course of two hours, with some little voice. This primitive "*localized*" galvanizing was thus repeated from day to day for a few more times, and which was attended with like phenomena, when the voice and power of the throat were perfectly restored. The loss of voice in this case, I should have said, was of several years' standing.

In the Dublin Quarterly Journal for February, 1847, is recorded a case much the same, and which was treated in the same manner, and with the same good result. But in this instance, the improvement in the voice began in the evening of the very first day, after the first application of the metal plates to the blistering on the sides of the throat. The case continued to improve until the fourth day, when the voice was again lost. But the process being repeated, and this time, moreover, the apparatus being allowed to remain on all night, this was fol-

lowed with the other effects in permanently restoring the voice, which continues.

Dr. Duchenne gives an account of two cases of hysterical aphonia, one of six months' standing, and the other of more than two years, both of which he treated and cured by the direct Faradaic use of electro-magnetism, *directed to the larynx.* He also makes mention of other cases of cures, but he mentions no failures.

Dr. Althaus, of London, appears to have had ample facilities for trying electro-magnetism in *hysterical aphonia.* Of the fifteen cases he saw, two were married, thirteen were single, and the most of them were under thirty years of age. In no cases, he says, were the signs of such a morbid state, either of inflammation or of ulceration of the larynx, as would have accounted for the loss of voice. But the affection consisted merely in the loss of power in the nerves and muscles of the larynx. One case, he says, was suffering from a venereal disease, and the merely paralytic character of the complaint might possibly have been overlooked. There was a syphilitic eruption over the skin, and a large node over the right eyebrow, so that by a superficial examination one might have been led to the diagnosis of aphonia, resulting from syphilitic ulceration of the larynx, but the signs of such ulceration were not present. A few applications of electricity proved beneficial. In some other of these cases, there was a thickening of the mucous membrane of the larynx; others had taken a cold just before; others did not know of any cause, but on awaking in the morning, found the power of voice gone. The voice was totally lost in all these cases, but some of the patients were able to whisper by movements of the lips and tongue. All complained of a sore feeling in the throat; four of them felt pain in or about the chest, and in the epigastrium; three were irregular as to the time of entrance of the catamenia, but amenorrhœa was not present in any one of them.. In two cases, aphonia was only one of the symptoms of a deep hysterical disturbance of the whole nervous system, for these patients suffered from globus, headache, cramps, &c. Dr. Althaus says, in order to give electro-thera-

peutics a fair trial in all these cases, he employed no other sort of medication. He used mild induction currents, mostly directed to the crico-thyroid muscles, and also to the recurrent nerves. This proved beneficial, for out of the fifteen cases, eleven were cured in a very short time. Faradaization proved unsuccessful in four cases, which had been of long standing. But in the eleven uncomplicated, which had not over four months' standing in any of them, he obtained the following results: One case was cured by one application of electro-magnetism, the voice returning in about three or four hours after the *seance*. Two cases were cured by three, and the other eight cases by four applications each. In six cases, when the voice did return, it was at once, and as strong as it had ever been. In five of these patients, there was an evident increase in the sonorousness of the voice, which was discernible from the beginning to the end of the treatment.

A severe and long standing case of aphonia in a man, cured by means of galvanism, is thus reported in the London Lancet: "Theodore M., 24 years of age, of sanguine temperament and robust constitution, had enjoyed good health until an affray, which was followed by a violent fit of epilepsy, and the sequel of this was entire loss of voice. To restore this, local and general bleedings and antiphlogistic measures of all kinds were employed without effect. The tongue was now enlarged, reddened, and dry, and the blood vessels around its base were much distended. Taste was still perfect, but the movements of the tongue and of the larynx were performed with the greatest difficulty. Leeches to the sides of the tongue, and other active remedies, as tartar-emetic plaster, was placed over the larynx; but all these means failed to restore a healthy action in the parts adjacent. Sixteen months after the attack, the primary current of a battery of 50 pairs was employed, by placing the positive electrode over the cervical vertebræ, while the negative was upon the parts affected. On the first day, 200 shocks were thus given; and on the second day, 300 shocks; but no perceptible good or bad effects followed. Two days were allowed to elapse, and then a battery of 70 pairs of plates was used," (the kind of battery not given,) "so that some 300 shocks were at this time given. The patient was now

found acutely sensitive to the action of electricity, and a lapse of five days was permitted to intervene before its fourth application, which then consisted of 400 shocks, performed with the same battery."! The reporter of this case says, "Whether these shocks had been administered too precipitately, or whether his system had become more susceptible to galvanism, the patient, after this last application, became much more agitated, and subsequently fainted for a short time. Next day he suffered intense headache, his face was flushed, eyes lustrous, pulse full and strong, from which state he was relieved by copious bleeding. But he now, for the first time, gave utterance to hoarse sounds. After a delay of six days the battery of 50 pairs was again employed, and 300 shocks more were given. The same treatment was repeated every two or three days, and then, at similar intervals, 400 shocks were given with the 70 pair battery. The voice, meanwhile, and the motive power of the tongue and larynx, gradually returned to their normal condition; and after the twelfth such seance, the patient was completely restored. The deduction drawn from this, by the surgeon who has reported the case, is, that no nervous affection whatever should ever be regarded as incurable, until electricity, in some form or method, has been fairly tried and found to fail."

I have quoted the foregoing case, not as an example of treatment, by any means, but to show an heroic procedure, that should rather be avoided than imitated. Supposing the galvanic battery to have been the most mild, i. e., constant, — as, for example, the improved Daniell's battery, and only twenty-five cups were used, — if directed by a *small* electrode to the trunk of the affected nerves, with some dozen interruptions for three minutes at each seance, I believe the same good result would have followed, without the least hazard. And probably it would be better still to employ electro-magnetism first, by means of small electrodes directed *stabile*, to the trunk and branches of the nerve affected, and then finishing the seance by employing larger sponge electrodes *labile*, both over the throat, cervical plexus and region, as well as over the throat and down the sternum.

Professor Sedillot, of Strasburg, lately brought a case of complete dumbness and aphonia ("deaf and dumb") of twelve years'

standing, which he rapidly cured by means of electricity, before the Academy of Sciences of Paris.* The details run thus: "The patient, a woman 30 years of age, had been visited 12 years before admission, (Nov. 19, 1855,) with complete dumbness and aphonia, in consequence of a fright. Various modes of treatment had been tried without success. The patient understood every thing said around her, and answered by gestures, but could utter neither word nor sound. The tongue was retracted and directed upwards, the woman not being able to bring the apex of the tongue in contact with the teeth. Deglutition and general health good.

"Professor Sedillot suspected here a paralysis of the muscles connected with the *cordæ vocales*. Inductive electricity was therefore prescribed. One pole was placed alternately on different parts of the tongue, while the other electrode was on the mastoid process, or under the lower jaw, or on the superior and posterior region of the neck, or on some part of the face. Some pain was thus experienced, but the tongue moved more freely. The first sitting lasted merely a few minutes, and was not repeated until one week after, owing to a severe headache which had followed the application. After the second sitting, the tongue could be protruded between the lips, and the patient began to talk distinctly, though the voice had not, as yet, quite returned. Pain was experienced in the region of the styloid process and the hyoid bone, when efforts at articulation were made, depending, very probably, on the *fatigue* of the muscles which had but just recovered their tone. The improvement became more and more manifest by a few more sittings; and a fortnight after the last *seance*, the patient returned home, perfectly restored. Several cases of recovery of speech by the means of electricity have been recorded, but none in which the affection was of such long standing, and then so rapidly cured."

The author could add here quite a list of cases of nervous or atonic "loss of voice," both in the hysterical and others, that have been successfully treated and cured by the application of

* Braithewaite's Retrospect, No. 34, p. 30.

electro-magnetic currents to the throat, tongue, and parts affected. Cold air blowing directly upon the uncovered neck appears to have been the cause of this affection in some of these cases, while various debilitating causes produced the affection in others. Over-singing, or going immediately into the cold after speaking or singing, bad dentistry, or *slight* chronic bronchitis appears to have preceded one and another troublesome case. Dr. H. I. Bowditch sent to me the past winter a patient with complete *aphonia* for electrical treatment — a Mrs. K., twenty-eight years of age, who had overtaxed her voice at a social gathering. This lady was a mother of three children, and herself appearing to be, otherwise, in excellent health; but her voice was totally gone, and had been so for months, in spite of medical treatment and patient waiting.

The *treatment* for the foregoing case was performed exclusively with the electro-magnetic current. The *seance* was usually commenced by using large moist sponge electrodes, and placing the positive on the back or side of the neck, while with the negative one *labile*, i. e., as it were, bathing the throat, the upper sternal region, and the upper portions of the pectoral muscles with this brisk current of electricity for about one minute, to work up a degree of susceptibility; then these were replaced by very small and covered metal electrodes, or small sponge-tipped ivory electrodes, which were planted, the one on the middle posterior border of the *sterno cleido mastoideus* muscle, while the other was swept along over the front of the throat, producing as strong throat muscle contractions as possible, first by a down-running current, then by an up-running one, but occupying certainly the most of the time of each sitting, (which was some five or six minutes in all,) with the current running downward, or direct. This was reversed from time to time — say five or six times during as many minutes. It was repeated daily, and then every other day, for a fortnight, when there was a marked improvement. From this time the voice returned gradually, so that in two months she could sing with the same sweetness and power as ever. The *gradual* restoration led me to reckon this as more a case of local muscular atony, than a pure "nervous" affection; for the

hysterical cases, so far as my observations go, recover *instanter* when they do at all. The *Humboldt battery* is capable, of itself, to work a cure in the nervous cases, if simply worn a part of the time.

Dr. Charles A. Lee, of New York, testifies decidedly in favor of the more frequent resort to electro-magnetism in the various partial palsies that occur, as the sequels of various diseases. He says, "I have certainly derived signal benefit in very many cases of local palsy, from the employment of electricity applied to the paralyzed muscles in currents of moderate intensity, gradually increased in force during the *seance;* and although there are cases that will not be so benefited by it, yet there are others which will yield most readily to the judicious and repeated applications of this remedy."

Finally, I lay it down as a *rule*, that, in all such cases as admit of the external and internal use of *stimuli* or *tonics*, as in the asthenic and more chronic cases, such are also proper cases to receive prudent trials in electro-therapeutics; and currents of moderate electro-magnetism are my *first choice*, usually, for this purpose. If this is received favorably, (i. e., for the better,) or even negatively, (i. e., harmlessly,) say for two or three *seances*, then I conclude that still more good may be developed by the *disturbing*, chemical action, or from the direct *catalytical* in-working of galvanic currents, or even from stronger currents of induction, or from static shock, or sparks drawn from the throat muscles.

*Aphasia* is not aphonia, although it is a loss of speech. Doubtless it has a central cause, being but a symptom of an actual brain lesion; it may be a faulty or perverted function. There is a normal condition of the vocal cords, as seen by the laryngeoscope, and an integrity of the understanding; but *the faculty of making and uttering words* is imperfect, or completely abortive. It is a brain affection, of varying degree.

Case of honorable Mr. D., aged fifty-five, merchant of Boston, married; nervous active temperament, but stout built and always rugged; came with his wife in haste from Washington, to see me for this strange affection, which was fast increasing upon him. It was in the winter of the second year of the war,

after an excited debate in the House, which held to a late hour; he awoke the next morning without the power of *reading* the newspaper, but in every other respect as well as usual. That is, in one night he lost simply the meaning of letters — syntax — so that while he could see, and speak yet perfectly well, he could not put letters together so as to spell out words. He miscalled the letters; that is, he said *p* for the letter *t*, while *v* he called *b*, and *ph* he called *f*, and so on. In a few days, he had to look some time at the letters to make up his mind what they were; and then sometimes it would be called right, and sometimes wrong. On a bright, clear day, early in the morning, he could sometimes read correctly a short paragraph of a telegraph; but this all soon failed him, so that he faltered, and then failed to speak intelligibly. Ten weeks after the attack, having seen many distinguished surgeons of the army, he came, as I said, in this singular and pitiable condition. He is a large, good proportioned and sized man, blue eyes, brown hair, and of unusual business activity and capacity. On investigation, I found he had been raised to the dry-goods business here, but was at the time, also, a heavy dealer in metals and stocks; a conscientious and correct man in all moral relations and habits of life, excepting the use of tobacco, which he had used until the past year.

*Treatment.*—I required that he remain one month in Boston, to have every other day sittings, and to leave off business utterly. I applied the inverse *galvanic* current of twenty-five cups of Daniell's, for ten minutes, from the coccyx to the nucha; at another time from the umbilicus to the ear, first on one side, then on the other; electrifying the throat at each sitting. He tasted it often, and sometimes saw flashes while it was running. He took one pill a day of both *formulæ* 7 and 10. At the sixth sitting he showed improvement; and at the end of the month he was learning to read. His business and speeches were then *proscribed* for six months more. He is now, two years and more since, as well as ever.

Soon after this case, came that of General Arnold, by the advice of Dr. Townsend, who, at the retaking of New Orleans, fell for-

ward on his horse, while in the field with troops, from over-fatigue and sun-stroke; which left him with no apparent brain lesion, but in this embarrassing predicament, of which I did hope and expect he would more rapidly recover; but which, it is well known, still somewhat afflicts him.

Another case only I will give of this rare and unique malady. Mr. B., aged forty-eight, thick set, dark skin, hair, and eyes; a shipping merchant; accustomed to close and ceaseless application to business, and always able to attend to it. Some six months before, after some unusual perplexity, having had a little sore throat about that time, he suddenly lost his speech. He seemed impatient by times, because he could not speak, and at other times would laugh at his predicament. He could think and plan quickly enough, and understand others. This went on for nearly a month, when he found it so difficult even to write what he wished to say or ask, that he finally gave that up. It was sad to see him labor and fail to make words with pencil and paper, for his perseverance was truly wonderful. He had perfect use of his hands, and all his limbs, and his mind was clear, with powers of perception and judgment good. But on the whole he was rather melancholic.

Supposing this, too, a case of aphasia, and no serious brain lesion, but some phase of loss of the dictating or telegraphing power of the *will*, I advised no business, sea bathing, cold sponging, riding, and cheerful company; to take one pill in the morning of formula number 9; and one pill at night of formula number 10; to visit my rooms twice a week, as he could easily come from Nahant. The same method of applications of electricity as for the first case, was adopted. In two months he began to improve; soon he could read the large letters on bank bills correctly. But after a while he found he must be re-educated; so he set himself to work to learn to spell and read. During all this time his memory, and almost every other faculty, was good, excepting *language*, written or spoken *by himself*. It is now nearly two years, and he is still troubled in his speech, reading and writing *but a very little*.

### *Spasmo-Paralysis in Childhood.*

In early life, from certain but not very clearly defined forms of disease, involving parts of the cerebro-spinal system, one set of muscles in a member may lose the power of contracting, and become relaxed, or even paralyzed, whilst the antagonist muscles more or less speedily manifest a disposition to contract; or else that the muscles on both sides of a member, (flexors and extensors,) without any distinct paralysis in this case, lose something of their power of acting under the will. A state still more often occurs of half paralysis and half spasm, to which the late Dr. Marshall Hall, first, I believe, applied the term "spasmo-paralysis," the consequence of which is, that the stronger set of muscles, commonly the flexors, acquires a preponderance, contracting the limb in the direction of their action, and that more usually occurring in the leg.

To such causes, partial paralysis and spasmo-paralysis — the majority of the contractions of infancy and childhood — owe their origin. If the *tendency* to contraction be borne in mind by the medical attendant, its prevention may be effected. If the contraction be discovered when nascent, its further progress may be interrupted by suitable treatment, viz., attention to nutrition, and the general health, especially to the condition of the alimentary and nervous system. This is aided by *local remedies*, such as adequate covering of the part, in order to maintain, if possible, a proper temperature — (I say, *this must be done*) — also, by periodical manipulations, so as to insure the limb being thoroughly put through all its natural movements daily, once at least, or oftener; and by a studied use of the member, so as to favor relaxation, or coerce elongation of the contracted parts, and to acquire strength in those of that set which are weakest.

By the use of such means, it is my experience, the greater number of paralytic or spastic contractions that are acquired during childhood and adolescence (growth) may be obviated or arrested from being worse; the exceptions being cases in which a more than usually severe paralysis, or an active tonic spasm, affects some or all of the principal muscles.

Mark, — so long as the medical practitioner has simply to do with paralysis or spasm, and an amount of contraction *susceptible of yielding to the pressure of the hand*, or even to the moderate use of some comfortable mechanical contrivance, calculated to maintain the member by times in a proper position, the rational surgeon will not affirmatively entertain the question of "division of tendons;" for, surely, the *division* of muscles affected with paralysis, or with spasm, is no cure for these diseased states. Indeed, in many instances the contracted muscle is a healthy muscle, shortened merely from want of action in its antagonists; and it is certainly inconsistent with sound therapeutics to endeavor to reduce by tenotomy a healthy muscle to the equal condition of a paralyzed one.

Moreover, the apparent benefit derived from division of the tendon of a muscle, itself being healthy, but possessing an inconvenient activity, *is only temporary;* for after a few months' time, the muscle (in children) *re-contracts*, unless the practitioner has determined to prevent the healthy muscle recovering tone after its division, by sedulously keeping the ends of the divided tendon as far as possible asunder — an effort often frustrated by nature, causing *slow* contraction in the newly-interposed or uniting medium. Instead of operating by tenotomy, in such cases, we are bound rather to exhaust all legitimate modes of counteracting the paralysis; remembering that during childhood and growth, there is ever hope of at least partial recovery from the paralysis. But when the case may be justly termed "incurable," then, even, mechanical supports, by means of elastic substances, steel springs, or rubber, may aid the weak member to perform its office.

It has so often happened, that while such a patient has been under treatment, by *tenotomy* and the subsequent mechanical treatment, say during a period of ten or twelve weeks, or months, that the paralysis of the non-divided muscles has partially or wholly disappeared, justifies the opinion that the same period occupied by proper treatment, *without* the preliminary tenotomy, would have equally witnessed cessation of paralysis, and consequent cessation of the contraction and deformity, by the restoration of antagonistic and associated muscle-action of the respec-

tive parts. That this result would have ensued, is not merely an opinion, but a matter of observation, in similar cases treated without tenotomy.

Until the age of ten years, varying according to constitution and growth, the majority of paralytic and spastic muscle contractions may be subdued by mechanical and other physiological means. As after preliminary tenotomy, the same mechanical means and physiological treatment are here for an equally protracted period desirable; i. e., until recovery from the paralysis or spasm takes place. Unnecessary tenotomy has not really the merit of even saving time; for although, *at first*, a rapid alteration of the form or mobility of the affected muscles and articulation is produced, which operates very favorably on the minds of the bystanders and friends, it after all is often an ultimate delusive benefit; often acting injuriously also by detracting attention from the other important modes of treatment. The *division* of tendons in paralytic contractions and spasmo-paralytic contractions is indispensable, when the contracted muscles have undergone *structural shortening* — a state in which, besides constant contraction of collective muscle fibres, whether resulting from loss of antagonism, or from spasm, (tonus,) the individual muscular fibres, after the lapse of several years, probably not less than six or seven, — more rapidly, however, during childhood than after puberty, — have undergone an interstitial change, the nature of which is imperfectly known, apparently consisting of adhesions amongst themselves, degeneration, atrophy, and adipose transformations, which render the aggregate muscle incapable of elongation by ordinary moderate mechanical extension. This state of "structural shortening" of muscle may be known by the long duration of the contraction; by the sensation of *rigid*, inelastic, cord-like resistance that is offered to the hand of the examiner; and by the shrunken, wasted condition of the muscles, volition not necessarily being entirely absent in such.

The advantages of division of tendons in older persons and longer standing cases, i. e., where there is structural shortening of muscles, and consequent limitation of movement and functions of articulations, with deformity, cannot be exaggerat-

ed. These are the cases in which the greatest permanent benefit accrues to the patient, and to the future reputation of the surgeon. When the previously contracted, *structurally shortened muscles* are divided by sub-cutaneous tenotomy, they evince *then* comparatively little tendency to re-contraction.

On the contrary, especially during childhood, when the contracted articulation can be moved through a considerable portion of the natural range of movement; when the resistance is somewhat elastic, instead of being rigid and unyielding; when in the foot, for example, the patient, by throwing the weight of the body upon the member as in the act of lounging in fencing, can bring the knee over the point of the foot, (toes,) when the atrophy of the member does not amount to, or approach to, a loss of one fourth in its circumference,—then tenotomy is not required.

The means by which, in such cases, tenotomy is superseded, are those already recommended — diligent, painstaking manipulations, appropriate mechanical supports, and appropriate (muscular automatic) exercises.

The whole muscular system is so arranged and balanced that on any one part of the body, or of a limb, we find one set of muscles for a particular motion, and on the opposite side we find another set for the opposite motion. This is a *law* of muscular arrangement and motion: on one side of a limb are the flexors, and on the other the extensors; on the one side the pronators, and on the other the supinators; the adductors and abductors, and so on. The *power* of the respective antagonizing sets are by no means equal, although the *habitual function* of counterbalance for each other *is* very nearly equal. Now, if this functional equilibrium is disturbed, the counterpoise is lost, and the limb is drawn towards the stronger and *prevailingly* contracted muscles, and consequently the extended antagonisms are thrown quite out of their field of action. As a general rule, the *flexors* are stronger than the extensors, the pronators are stronger than the supinators, and the adductors are stronger than the abductors. For this reason, we are inclined to the modern view that the *gastrocnemii* and *soleus* muscles of the calf of the leg are the *flexors* of the foot; such,

in fact, is the nomenclature adopted by Dr. Detmold, of New York, as also by MM. Rudolphi and Von Walther.

According to Dr. Detmold, the club-foot that results from *spasmodic* contraction is more difficult to cure than any other.

The club-foot after *paralysis* of the muscles is much easier cured, but it necessarily requires a long time.

The club-foot from *gradual* muscle contraction, if without spasm or paralysis, admits of the most favorable prognosis, such being far more readily cured.

In treating all proper cases of *contracted muscles*, from whatever cause, we find the *law* that electric currents run downward through the most palsied, atrophied, and contracted flexor muscles, for not more than a minute at a time, then allowing a recess of a few seconds, and again applied running upward through the antagonizing muscles for a quarter minute, and thus reversed and alternated some half a dozen times at the sitting, as a general thing, have the best effects for dissolving all such chronic contractions or *tonus*-state of the muscle fibres, and gives the best results. This is proved, not only by the good result, but also, I think, from the opposite law, which is, that an up-running current, for one minute, that is then reversed on the antagonizing muscles for a quarter minute, (so as here to run downward for only a quarter minute,) and then up again for one minute, and so on reversed and alternated for some time, can ultimately work up a state of *tonic* spasm. The conclusion that we should fix in our mind is, that the down-running current, that is maintained, say for a minute, running outward, from the brain and cord, towards the periphery and extremities, *affects the sentient nerves* of the part so acted upon more than the motory; and that the up-running current, that is, *running towards* the spinal cord and the brain, *affects the motor nerves* and muscles more profoundly than the sentient nerves, and that probably through *reflex* action.

*Wasting Palsy of Childhood.* — Wherever there is loss of nerve power, there is imperfect development; if *perverted* nerve action, then we see also atrophy. There is a class of these latter cases, among which there is *complete paralysis with atrophy*

of the deltoid muscle, occurring in childhood during dentition, the result of some morbid reflex action on the nerve centres or roots. This affection, the "*essential paralysis of childhood*," may arise, doubtless, from a combination of bad influences, or from an influence to which the system is just then peculiarly susceptible — as an undue use of mercury, lead, or arsenic; or from worms, or improper food, or simply from the teething. These cases are rare; but I have recently had another complete example in a fine little boy of Charlestown, which the engraving shows very well. The palsy comes on suddenly, the shoulder speedily loses its roundness, the upper arm becomes flaccid and lax, the deltoid, *more* than any other of the shoulder's muscles, rapidly wastes away. In a few weeks, or months, the head of the humerus actually falls out of the socket of the scapula. The arm now hangs loosely, so that the thumb and finger can easily pinch the thin and soft tissues together in the place of the joint, between the bones, where should be the head of the arm-bone in the glenoid cavity. There is always great *sensibility* to the action of electricity.

Fig. 131.

In this case the muscles of the fore-arm and hand retained their normal law or order of development, with little diminution of solidity; and what was very remarkable, in such an appearing arm, there was, and is still, some power to grasp and move the wrist and fingers. In other cases the muscles of all the arm and hand are more or less atrophied as well as palsied.

No treatment here seems to be of any use, *after* this stage has arrived. Complete loss of lean meat or muscle fibre is replaced only by yellow fat, and there is nothing left to make muscle from. Earlier in the affection, or wherever we are not quite sure of this complete condition, we are justified in trying moderate galvanic and faradaic currents through large sponge

electrodes directed to the cervical spine and the most wasted shoulder muscles, every other day or twice a week, alternated with *mellowing* and *deep-shampooing*, which should be performed twice a day; prescribing *formulæ* 7 and 9, (half pills,) or prescription 6.

*Paralysis of the Spinal Muscles.* — This affection may be known, —

1. In the early stages, by slight incurvation of the spine; in the later stages, this is so great that the head inclines forward, or actually rests upon the breast.

2. Impossibility to maintain the erect posture without some support.

3. Dull pain in the lumbar region, increased on long standing, and diminished by lying down; in some, neuralgia affects the intercostal nerves; in others, loss of sensibility of the skin alone down the spine.

4. Some painful points may exist in the lumbar region, but they are owing, probably, to stretching of the ligaments which have lost tonicity.

5. Incomplete power of extending the trunk without a fixation of the upper limbs.

6. Alteration in the natural curves of the spine; the concavity backward of the cervical region being the *first* to disappear.

7. Right (usually to the right) inclination of the spinal column.

8. Freedom of movement of the cervical muscles when helped, except the above-mentioned incurvation; late in the disease, excavation of the vertebral gutters, so that the vertebral extremities of the ribs may be more or less distinguished.

9. Increased mobility of the vertebræ, one upon the other, owing to relaxation of the muscles, attended by occasional noise like the crepitus of certain dislocations.

10. Finally, it is known by the incomplete straightening of the spinal column by smart faradaization of the muscles of the whole back. Strongly electrifying the muscles of the back is a grand remedy, which can be aided by dry cupping. The treatment should be much the same as for rheumatic palsy. (See p. 807.)

### *Progressive Wasting Palsy.*

This affection has but a recent history in medical works, as the earliest well-defined cases are limited to the present century. In 1795 was delineated to the medical world the first example known. But we are often led to query what could have been the nature of those cases of "withered hand" which received, at the hands of Christ, the compassionate cure by miracle? Says Sir Charles Bell, "This is an obscure subject." To this day, it is looked upon by physicians, that wasting palsy is owing to "defective nutrition;" but it is evidently more than this, for there is a rapidly progressive *diminution* of both bulk and power of the affected muscle, or muscle group. There is — there must be — some *mal*-nutrition, some perverted and devouring action.

Says Dr. Roberts, of London, cases of excessive wasting palsy of the muscles of one or more limbs, *independent* of any well-defined *cause*, have, from time to time, been observed; and records of these are found scattered in various medical works. They have been, until recently, introduced as "*extraordinary*," or anomalous cases, and are referred to in systematic treatises as "creeping palsy," or as "lead palsy without lead," "peripheric paralysis," or "local palsy," or "progressive palsy."

This progressive wasting paralysis does not extend to neighboring parts of the leg or arm, nor is it a kind of blight that reaches so far up the limb, or so far down the limb, *but it is a morbid affection of muscles* acting under *a law of election*, that limits the progressive wasting to those muscles only *that are naturally combined in action*, although these muscles lie in different parts of the extremity, and are supplied by different nerves, as they are also supplied by different arteries. For example, the muscles of the thumb may be affected by this disease, but the wasting and palsy will not be confined to the short muscles of the ball of the thumb, but will, rather, extend to those long muscles of the thumb which lie upon the forearm; and these wasted muscles are seen lying side by side with those that are plump and powerful. In another case, all the exten-

sor muscles of a group, or of a limb, will waste away and lose their power while the flexors will preserve it; and this usually produces a characteristic position of the limb. I am inclined to agree with the early views of Sir Charles Bell in attributing these very partial freaks of disease to *visceral irritation*, and in that case it must be through the sympathetic nerves, just as we might expect. He evidently had distinct and well-defined ideas about these cases forty years ago. He correctly grouped them together, and yet, apart from all other kinds of local palsies, such as arise from injury of the spinal cord and nerve trunks, or from lead. In 1849, M. Duchenne, of Boulogne, presented a memoir to the Institute of France, entitled "*Atrophie musculaire avec transformation graisseuse.*" In 1853, M. Cruveilhier read *his researches* on this subject before the *Academie de Medecine*, and so graphic was the delineation of this mysterious malady, that progressive wasting palsy has been termed "Progressive Paralysis of Cruveilhier," or "Cruveilhier's Atrophy."

This is a truly formidable disease. What produces it immediately or remotely we cannot tell. It may occur without the least assignable cause in persons who have met with no accident, and are otherwise in perfect health. Wasting palsy may affect children and adults, male and female; but it is suspected to arise, sometimes, from protracted fatigue of certain muscles; also from bruising, and from cold. It is almost always of slow invasion, and is usually discovered first from the sensible loss of power; for by this, the attention of the patient or friends is drawn to the state of the muscles, when, perhaps, they are discovered to be already wasted, or soft and degenerated. There is also noticed, at times, a violent *quivering* in these muscles, which does not cause motion of the limb, nor any kind of pain. This *quivering* does not attend all cases of this malady, but when it does occur, it indicates that the disease is still advancing, and if it ceases, the disease is arrested, or the muscles are already totally destroyed. Some of these patients complain of vibrating cramps that prevent their sleep, but such are quite distinct from the tremblings. The muscle, or clan of muscles, is progressively destroyed, while the nerve branches, even down to the affected muscles, are at first apparently sound, and

the general nervous system appears to be quite healthy. The attacked muscles appear, on dissection, of a pale-yellow color, are wasted as to *number* of fibres, and their bulk is often reduced to mere thin cords. Fat, which is always produced in degeneration, or retrogressive metamorphosis of tissues, become accumulated, in some of these cases, so as to fill up the place of the consumed or missing muscular fibres. In these cases there is not seen the remarkable wasting that is so apparent in others, for the limb may appear nearly, if not quite, as plump as before the attack. But where the sarcolemma, or sheath of muscle fibres, has actually been consumed in the morbid process, the sarcous elements become converted into fat and granular matter, and the last ramifications of the motor nerves there distributed become affected, and perhaps perverted, or were perverted at the onset of the malady. In some cases the fat is eliminated probably as fast as formed, and hence the extreme emaciation. It is supposed that this affection does, in some instances, extend along the motor nerves to their formation of the anterior root of the spinal nerves, and even atrophy of the spinal cord itself may finally be the consequence, but never the *cause*, of the primary affection. If this is so, did not this constitute the true "Tabes Dorsalis" of the more ancient medical writers?

Wasting palsy appears in two forms — the *partial* and the *general*. The partial form begins usually in some of the muscles of the hands or shoulders, with a tendency to spread to the body, and so threatening life. If it commences in the hand, it is usually in the right hand, and the muscles of the thumb are first affected. The belly of the thumb gives place to a great hollow space between the first and second *metacarpal* bones, and next, the *lumbricales* take on a state of tonus, or rigid contraction, drawing the fingers like claws, while the *interossei*, and also the *thenar* of the thumb and fingers, and the *hypothenar* eminences of the palm, are atrophied. Then from the hand the disease extends up the forearm. The extensor muscles of the fingers, situated on the outside of the forearm, are by far the most liable to be affected; but the flexors are, in some cases, likewise destroyed, or they alone may be affected. In this case

the fingers are bent upon themselves, and so retained, much like claws, while they cannot bend upon the hand so as to grasp or hold.

If the invasion of this terrible and insidious disease first affects the shoulder muscles, and by way of its usual preference, wastes, first, the *trapezius*, then the *serratus magnus*, the *rhomboide*, and those other muscles that hold the shoulder blade to the thorax, and in its natural place, then the outer angle of the *scapula* becomes depressed by the weight of the arm, while the lower angle is raised and projected widely from the body. The disease then spreads down the shoulder to the arm, wasting and palsying the *deltoid* and the *biceps*, which leave the shaft of the *humerus* near the surface, and the *acromion* and the *coracoid process* very prominent under the skin. The patient can no longer raise the arm, nor even feed or dress himself. It may then pass into the general form, sooner or later, and thus speedily cause death.

Then, again, if the invasion is of the *general* character, it will make its appearance in the muscles of the lower extremities, which will be first discovered from the fact that walking has rapidly become difficult, and as rapidly the muscles are found to have wasted away, and then the movements soon become quite impossible. The muscles of the thighs go first, and this wasting extends up to and through the spine, so that, next, the *pectoralis major* is found already consuming away. In this form, it is noticed, that all the voluntary muscles throughout the organism may be affected by it, excepting only the muscles of the eyeball and the muscles of mastication. But, when we see the ravages of this malady already wasting the *facial muscles*, then we know we have a certain sign that the disease, in that case, will shortly prove fatal. That is known by the whole physiognomy losing its expression; and sometimes the saliva drools from the lips. The speech is very slovenly and slow; swallowing difficult; the diaphragm loses tone, and respiration is feeble. The slightest impediment to respiration, now occurring, most generally closes the scene.

Wasting palsy is not a "self-limited" disease, in the common acceptation of that term, although in one peculiar sense it is

so; but it is rather a chronic affection, and that in its profoundest signification. Its *tendency* is to death, although in some rare instances it is arrested, so that recovery and years of health may follow. It is scarcely necessary to say, that in such a disease, the more recent cases — i. e., after a lull in its progress — are the most hopeful for recovery. Consequently the more recent and partial cases are to be taken for hopeful treatment, rather than those of long standing. The currents of Galvanism or Faradaism, are the only, or certainly the most powerful, means known for arresting the progress of this affection, and turning the tide of adverse bodily action into a healthy direction. That certain cases, and particularly such as are of the general kind, do run their fatal course in spite of electro-therapeutics and all other treatment, is to be expected. Yet I always treat these cases as early and thoroughly as possible, for now and then there is most marvellous improvement, and even recovery.

*Wasting progressive palsy* is by far most frequently met with as a local palsy, and seen oftenest in the right shoulder, or right hand. Nearly three quarters of all the cases I have been called to treat have been such; more of the shoulder, or of the shoulder and hand, than of the hand and fore-arm alone. The deltoid, the trapezius, the biceps cubiti, pectoralis major, serratus magnus, are, in about the order named, the greatest sufferers. If the disease *begins* in the hand, the adductor muscles of the thumb are the first wasted, showing a hollow space between the metacarpal bones, where the belly of the adductor should be. Later still, and the lumbricales and interossei melt away, leaving a horrid appearance. The affection is next shown in the fore-arm. Next, if the disease is neglected, and is still progressing, the triceps and the deltoid gradually diminish in size and strength. If the posterior fibres of the deltoid together with some other shoulder muscles are attacked and waste fast, before the pectoralis, coraco-brachialis, and other antagonizers, there is produced *sub-luxation*, forward and downward, of the head of the humerus, out of the glenoid cavity. A sub-luxation, I say; for reduce it as thoroughly and as often as you may, before this morbid process is arrested, and still is it a sub-luxation.

The nerves of sensation are very rarely diminished; but very frequently are increased in susceptibility to the impressions of the electric current; and for this reason the more care is requisite in making applications to children patients.

When such a case of this formidable disease presents for treatment, if there is a physiognomy that appears cold, expressionless, and emaciated, it is to me a pretty sure sign that it is the general form, and that the case *will prove fatal*, and that speedily. Sometimes, from a great distance such pitiable objects will come too late, as a *dernier resort*. They are invariably advised, however, to lose no time, but return immediately, and live as long as they can at home, and among their friends. For when the disease has once seized upon the facial muscles, I have never seen a recovery; and I think this is the experience of all who have had much to do with this class of patients.

Evidently our first work for such a patient is, if possible, to put a stop to the "*progress*"—shall I say to the morbid *tendency towards muscle-consumption, growing-palsy, and death?* Recent cases are more likely to be arrested, and then rescued in a complete recovery, by means of electric treatments, than those of longer standing; consequently, when a new case of this muscle-consumption, with growing-palsy, presents for electric treatments, my most anxious inquiries are, first, if the case has been of long standing; and second, if there has been muscle *fibre-trembling*, or quivering; and if so, whether it has continued to the present time. These rapid seesaw movements of small bundles of muscle fibres produce no movement of the limbs, and are by no means painful; but are rather sometimes amusing, annoying, or alarming to the patient, according to circumstances. But I think it has been the experience of all careful observers of this malady, that while or as long as this peculiar muscle *fibre-trembling*—"*flesh-quivering*," as the patients sometimes term it—is still occurring frequently, (that is, from time to time,) whether before the treatments, or during the days of treatment, the *progress* of the disease is still going on. This fact is important, and is to be taken into the account in diagnosis and prognosis. And yet, when it ceases, even if during treatment, we cannot but be solicitous for a time, for who can tell whether

it is evidence of the final destruction of the last vestige of muscle fibre, or of the arrest of the disease, which is to be followed by recovery?

Hence, the utmost caution should be observed, to make the first electric sittings short, moderate, and correct; and to carefully regulate the violence and duration of rubbing, and deep-shampooing, and the gymnastics; as any of these means, when pushed too far, can prove a damage instead of advantage. Now and then we shall find a case that suffers from cramps, which are also critical symptoms; but they are entirely distinct from these peculiar quiverings. Treat these crampy cases also, but gently, daily, and perseveringly. *Mellowing*, alternated with *primary* or *secondary* currents, can urge an afflux of blood to fill and moisten the sick soft tissues, which will nourish that which is ready to perish, and wash away the worn-out matters. Thus we afford the best possible chance to vivify the few remaining nerve twigs and muscle fibres, and to increase the natural warmth and the growth of fibre cells out of the re-absorption of the deposit. As long as there can be produced electro-muscular contractions, if ever so slight, there is still hope, and we are not to relax efforts, no matter how great the emaciation. Watch the effects; for the majority of these cases, if taken early, can be cured.

"*Ataxie locomotrice progressive*," — a progressive disorder of locomotion, — so named by Dr. Duchenne, is not so much a palsy as a morbid disease, or symptom of disease, essentially characterized by *a want of coördination of complex movements*. It may occur, doubtless, independently of palsy, or atrophy, or disturbances connected with either cutaneous or muscular anæsthesia. On the other hand, it does occur often in connection with palsy and other nervous disorders, and exists without discoverable lesion in the cerebro-spinal organs. But it is now ascertained that various anatomical lesions in the posterior columns, roots, and posterior horns of the spinal marrow, can produce this symptom, in varied degrees, in connection with derangement of the muscular system. Recent *post mortem* investigations lead to the impression that a morbid entity exists, having a slow and progressive progress, with a termination almost certainly fatal,

if not *early* arrested; and this, connected with a particular degeneracy of the spinal cord, occupying the seat above indicated, (near the base of the brain,) sometimes involving at last the motor nerves of the eye, as also the optic and other cranial nerves. The prognosis, therefore, must be encouraging, cautious, or unfavorable, according to the degree or stage of the disease and its complications.

This disorder consists, then, in a progressive abolition of the coördination of movement, with *apparent* paralysis, contrasting with the actual integrity of muscular force. The patient is not deprived of the power of motion, but he is of the power of controlling his motions. Hence, his gait is like that of a drunken man. He staggers as he tries to walk, or cannot walk at all without support. It is evident the muscles do not obey his will.

The person so affected always presents a *group* of identical phenomena. According to Dr. Duchenne, "there are the same symptoms, same progress, same termination. Thus, in the majority, paralysis of the sixth pair or of the third pair, a weakening or even a loss of vision, attended with inequality of the pupils, appear either at the outset, or are precursory to the disturbance of coördination of movement. Very characteristic *piercing* pains, wandering, erratic, of short duration, rapid as lightning, or similar to electric discharges, returning in paroxysms, and attacking all the regions of the body, accompany or follow these local paralyses. These phenomena constitute the first stage. Subsequently, after a time, varying from several months to several years, there appear, in the second stage, vertigo, difficulty in maintaining the equilibrium of the body, and in coördinating movements; soon afterwards, or sometimes at the same time, a diminution or a loss of tactile sensibility, (analgesia and anæsthesia,) at first in the inferior, more rarely in the superior extremities. Finally, in the *third* stage, the disease becomes general, and speedily fatal.

"During the course of the malady, there occur frequently disorders of the functions of the rectum and of the bladder, but without sugar or albumen in the urine. The intellect remains unimpaired; speech is neither hesitating nor embarrassed; the

electro-muscular contractility is intact, and the muscles undergo no alteration of nutrition or of their tissue. Ordinarily, too, this malady is *progressive* in the sense which Requin has given to the term, namely, that the disease has a *tendency* to become general and fatal." *

It is a question whether Dr. Duchenne was correct in pronouncing this affection as *always* progressive, and fatal in tendency. I have seen some cases that had a long history without a progressive character; and other unmistakable cases have I seen who are entirely recovered.

In true ataxie locomotrice, there is, in some cases, *amaurosis*, arising from alteration of the motor or optic nerve; or there may be simply *amblyopia* from the same cause — the cause of the ataxie. This all may be accompanied with severe pains, either in the eyes, arms, or legs. The lesion of the posterior columns of the cord, in these cases, is essentially a degeneration or softening, with atrophy of the nerve tubes or strands in the columns and posterior roots, and a similar alteration of the cellules in the gray matter of this part. Disease in the cerebellum produces phenomena *similar*, resembling this kind of paralysis; but it can be diagnosticated by Dr. Trousseau's method. Let the patient stand with the feet close together, and then direct him to shut his eyes. The *ataxic* patient will stagger immediately, and perhaps fall if not caught; the patient with diseased cerebellum will not *so readily* lose his equilibrium. In true ataxie, when the patient attempts to walk alone, and without cane, he projects his feet in any direction; and if the hands are also affected, he will sprawl his fingers, while one or two of them are flexed.

*Progressive Muscular Paralysis of the Tongue, Velum Palati, and Lips.* — These cases cannot be said to be frequent; yet Dr. Duchenne has seen thirteen, and reported seven of them, all of which occurred in his own practice since 1852. In these cases the paralysis of the tongue is the first symptom, and is the principal difficulty, as it hinders swallowing. From the diminished

* Electrisation Localisée, Paris, 1861.

ability of moving the tongue, there is a difficulty in articulating certain words, and finally total inability; the swallowing, at first a little interfered with, becomes difficult, as if the mouth were held open and the tongue forcibly depressed. The *velum palati* being affected, the "p" and "b" being sounded as "me," "fe," or "ve," owing to the posterior nasal orifice not being closed, the air from the lungs is divided, a part passes out by the nose, and the other part by the mouth; hence the peculiar nasal sound. Even food and drink are apt to find their way by the nasal fossæ. On inspection of the mouth, the palate is alike on both sides, and no other deviation is visible. If the patient pinches his nose while talking, the articulation is much improved.

This affection is first manifested in the tongue, next in the palate, and then in the lips; this order is pretty uniform. Now, the patient has a difficulty in pronouncing the vowels "o" and "u," as also a difficulty in kissing and whistling; the labials are imperfectly pronounced; and in some cases where the quadratus and triangularis muscles of the lips are paralyzed, the vowels "e" and "i" cannot be produced. The lips pout, and thus a doleful aspect is assumed by the face. Late in the disease a disturbance in the breathing is easily provoked, as by walking, or emotion; and suffocation may be so severe as to produce death by syncope. There are no febrile symptoms, and the digestion is undisturbed. The patient grows gradually weaker, partly from want of food, and partly from the same *central cause* which produces the frequent attacks of giddiness to which these cases are so liable. Only in one case has there been any paralysis in the limbs; no palsy of the orbiculares of the eyelids, or of the zygomatics, nor of the buccinator.

*The prognosis* of these cases, according to Dr. Duchenne, is usually unfavorable, for this kind of progressive palsy is always chronic, lasting from one to two or three years, and always advancing, not in any instance remaining even stationary.

*The diagnosis* in the earlier stages is not always too easy or sure; but later in the affection, after the palate and lips are involved, it is clearly recognized. It may be known from *pharyngitis*, because there is no fever or pain, no redness or swelling of the pharyngeal or buccal mucous membranes. In simple

paralysis of the *velum palati*, the dysphagia is never so entire as to hinder the swallowing of the saliva, nor is articulation so difficult. It may be known from paralysis of the seventh pair of nerves, because that occurs usually on one side, while this progressive palsy of tongue, &c., is equal, or nearly so; besides, in facial palsy the muscles of the eye and face are involved. But the most distinctive characteristic is the galvanic test by electro-magnetism; the integrity of the electrical contractility by quick response in the orbicular muscle of the lips distinguishes these insidious progressive cases from paralysis of the *portio dura;* for in this latter affection decided feebleness or entire loss of this property exists. These cases might be mistaken for the commencing stages of "fatty muscular atrophy;" but out of one hundred and fifty-nine cases of the latter observed by Dr. Duchenne, never once was the tongue affected by palsy and atrophy *at the commencement*, or in the early stages of the affection. The two affections might possibly occur associated, and so give a difficult diagnosis; for one such case is reported.

*Treatment.* — Faradaization of the affected muscles is the most likely to bring about amelioration. This should be resorted to in addition to any other treatment that may be thought necessary in the individual case. In one case now under treatment, the author is using mercury and iodine as specific alterative aids, as if tertiary syphilis, and the patient is recovering.

*Tabes dorsalis* is in fact an atrophy of the spinal cord. It is a disorder, the symptoms of which greatly *resemble* general cerebral paralysis. The first symptom by which it is known is the gradual loss of strength in the muscles of the inferior extremities. There is a wasting of the body, which is preceded by pain in the back or loins, and afterwards in the neck and head. It has been ascribed, in some cases, to too early and too frequent addiction to venery; but I think I find it most frequently in those who are naturally of feeble nervous constitution, which may have been *exhausted* by undue labor or bad atmosphere, by dissipation, tobacco, or cold and damp, &c.

The first marked symptom is an unsteady, pitching, clumsy gait, from failure of strength and control of the legs. The feet feel numb in standing and in walking; while the sensibility of

the skin, as respects heat, and cold, and pricking, remains as natural. If he shuts his eyes, or is in a dark room, he fails to walk still more markedly. The failure of power in this malady shows itself also in the unstriped muscles, as in those of the bladder and intestines. The intellect generally remains, but the sense of sight is apt to suffer. There are sharp pains shooting through the legs, and there is also gastric distress. Thus we see much resemblance between this affection and general cerebral palsy, and ataxie locomotrice progressive; but they are different, and we must see it in time for correct treatment. In tabes dorsalis we notice a dwindling of the muscles, but especially those of the nates, back, and legs, and their actually diminished force, and waning of the sensory and motory power, and diminished or lost electro-muscular response.

*Atrophy*, or muscle-wasting, may be general or local; it may be caused by disease, by want of nourishment, by *mal*-nourishment, or by a morbidly *devouring process*, from reflex action, attended often with a fatty degeneration. It is seen as the result of fevers; in *tabes mesenterica* and the marasmus of childhood; in the essential palsy of childhood; as the result of close confinement, as in prison; as the result of injury to a nerve trunk, as by rheumatism, by lead poison, or by sabre wounds; in *tabes dorsalis;* and it is seen also in old age. Now, all these are different in importance and nature, and require different treatment, for which see the different articles.

I frequently have cases of *local progressive atrophy*, caused by nerve injury or nerve exhaustion; as from pressure, bruise, or strain, or from some monotonous work that maintains a long fatigue of a limb or a group of muscles. The progress of this wasting is first fibre by fibre, then bundle by bundle, and then muscle by muscle, but leaving intact all general and special sensibility. As this atrophy goes on, of course there is a fatty degeneration, as described under the head of ataxie locomotrice progressive, which may be deposited in the place of the removed muscle fibres, or it also may be devoured away; and when the fatty supplanting is complete in the muscle, the electro-muscular contractibility is gone. But as long as there are the last

remaining fibres, there will appear this evidence, and that in proportion to the degree of atrophy or transformation.

Now and then we see a case of muscular atrophy from insidious disease of the spinal cord, as in the cervical or *dorsal* region. The arms and shoulders are fearfully wasted in a most rapid manner, and there is also a gradually increasing paralysis. There are no electro-muscular contractions; tickling the feet produces no reflex contractions. The arms become skin and bones, and perfectly helpless in a month or two from the attack; and yet perhaps a finger or two can be moved a little; there were first numbness and prickling in his feet, and the lower limbs can still be moved about while in bed, and the toes can be moved; but if he gets lopped over sidewise, by accident, while half sitting or reclining on raised pillows in bed, he cannot recover the upright sitting posture again without help. The speech is thick, the deglutition slow, and there is liability to choke from swallowing food or drink, and spells of difficult breathing, neuralgic pains, and poor nights. Finally he becomes totally helpless, and soon dies. All this comes on gradually, after a slight illness from fatigue, or cold, or both, within a few months or a year.

*Post mortem* examination shows general and most complete emaciation, but more in the upper extremities than in the lower. No effusion is found in the membranes of the brain or cord, and no disease elsewhere, except in the dorsal or cervical region of the spinal cord; which appears *pale and shrunken* to one third less than the natural size, as seen lying in its bony canal before being disturbed; and here is the source of a general muscle consumption, of palsy, and of death. No electric treatment would be of any sort of avail in such cases.

The indication in the electric treatment is much the same as that in lead palsy; i. e., to cause the muscles to contract as separately, as strongly, and repeatedly as possible, and yet without too much fatigue; to cause the dilatation of the capillaries at one moment, and the contraction of the blood vessels at another; and thus attract to, and urge more blood through those tissues, to warm and nourish them; and finally that by the chemical, or rather the *catalytical*, *action* of Galvanism or Faradaism, the mal-process of animal chemistry may thus be so

broken up and disturbed from time to time, and under such circumstances, that the ever-ready laws of vitality may arrange and re-arrange, and restore those processes again that we term natural and healthy. To bring about so desirable a result, *we must persevere for a long time*, even where no tangible improvement is produced, say for the first month or so; but so soon as it is found that we *thus arrest the further progress of the malady*, we shall be all the more likely then to improve further the condition of the patient, and very possibly to effect a cure.

Dr. Budge, in an interesting paper communicated to the French Academy in 1858, stated that he had ascertained that the actual number of muscle fibres increases with every year during the period of growth; so that the increase of muscular tissue does not depend alone upon enlargement of the individual fibres of the muscles. He has also discovered that starvation diminishes the *number* of the fibres, and also notably lessens their individual size. This answers the old query whether during growth, and the hypertrophy caused by healthy exercise, the muscular fibres of animal life increase in *number*, or merely in *size*.

M. Becquerel and M. Valerius are of the opinion that true and *still active* wasting palsy are not proper cases for the trial of electro-therapeutics. M. Duchenne, however, says that as long as the muscles show the least signs of electric response, even if only by the smallest fibril wave or contraction, and up to the period when fatty transformation is about to set in, he hopes for, and attempts by the aid of electricity the restoration; and it does seem to me, that here he has succeeded wonderfully, not only for amelioration, but for actual cure. But I find this end is easier attained where the atrophy is local, and where it is the effect of too close application, or rather from a work of unremitting *sameness*, that has overworked and exhausted a certain class or classes of muscles. When the case is spontaneous and general, and that without special cause, then I reckon there is far less hope, if any at all. We may, moreover, have presented to us for treatment a local palsy, attended with atrophy, first, from inaction, or, second, from over-action. The

former requires gentle and often-repeated exercise, with electric treatments; while the latter requires rest, automatic movements, and champooing, and this aided with electric treatments, to cure. These can usually be successfully treated, but are apt to remain feeble, and if overworked again they are very liable to relapse; hence the actual necessity of cautioning the patient or his friends.

Dr. Duchenne, who certainly has had very great experience with this class of cases, is disposed to believe that a new formation of conduction, or *capability of conduction*, here takes place in the nerves, much the same as is known to occur under favorable circumstances, through a cicatrix, so as to restore one way sentient nerve influence, and the other way motor nerve influence, and that with muscle contractions; thus not only arresting the progress of the disease, but even re-making or multiplying the individual muscle fibres. But this can only be hoped for when the cause of the disease ceases to act. He thinks that the electro-magnetic currents are, on the whole, best; that great *battery* power is required, and that with a very rapid vibration. The greatest obstacle to this method is, to persuade the patient to bear it; but as the sensibility increases, so must the intensity of the current be diminished. A sufficiently strong Galvanic (primary) current is very much more bearable than the Faradaic currents of the same strength — i. e., that can produce the same muscular contractions. For this and other important considerations, I prefer, for these cases, the former.

The "*essential paralysis of infancy*," affecting more frequently the lower limbs, may as well be classed with those of *wasting palsy*, for they, too, are characterized by a gradual wasting, but with a sudden paralysis; but the former cases appear to proceed rather from an affection of the anterior nerve roots, as they leave the spinal cord, and require our particular attention. May not this, in fact, yet be found to be the true pathological condition of the *general* form of wasting palsy? But Dr. Duchenne has treated many such infantile cases, and concludes that localized Faradaic currents applied along the *sides* of the spine, and over the affected muscles, may abridge the duration of the paralysis, and diminish, if not prevent, the attending

extreme atrophy of the muscles, and, moreover, prevent their fatty degeneration. Some of these run a rapid course to a hopeless state, and that, sometimes, in only a very few months. But more generally, within the year after the attack, there is hope; while, in any of the worst cases, we find that there is no evil from a reasonable use of electro-therapeutics. It is well therefore to try this treatment thoroughly, even where there is at first no electro-muscular response, as there may be a possible chance of success; for I have certainly found an occasional case that gave marked improvement, after years' existence of the malady; but of course the *progressive* character had then been arrested, and the case had long remained simply *in statu quo*.

### *Rheumatic Palsy.*

*Rheumatic paralysis* may in one case be found to affect one muscle, in another case many muscles; or it may be found involving nerve trunks with all the group of depending muscles. The history of the case aids us to recognize it, as by the absence of evidence of lesion of the great nerve centres; its occurrence in a rheumatic person, or after exposure to draught of cold air; it being limited, coming on rapidly, *and being attended with pain*. For example, we often see it involving the *portio dura* nerve, and thus producing facial palsy, with these characteristics. The electro-muscular contractibility, in recent cases, is very good, and electricity, moderately applied, can cure it; but if the case is of longer standing, so that the nerve and muscle structures have been altered by the rheumatic deposit, then electricity has little effect, immediate or curative, and the case will probably prove obstinate under any and every kind of treatment. But it may be discriminated from that grave palsy of the face, symptomatic of a disease of the brain, by the strictly *local* character of rheumatic palsy; by the absence of impaired sensation of the face; absence of headache; absence of vertigo, of mental confusion, or of loss of memory. In some cases, however, the *velum palati* may be involved in the simple local palsy of rheumatism; but we can feel the rheumatic induration in the skin of the face.

Rheumatic palsy may appear as a partial, or complete palsy;

but most usually it is known as preceded by pains and weakness, and in being followed by contractions and atrophy. It is most liable to be mistaken for *lead* palsy, as it very frequently is seen in the arm and shoulder; but it may be diagnosed from it by the *unimpaired* electro-muscular contractility and sensibility. Moreover, rheumatic palsy, as it is called, — which, by the way, is a name given to a large class of local palsies that may occur in any part of the body, head, neck, or extremities, sometimes following neuralgia and debility, and probably most frequently following exposure to cold and wet at a time when the part was peculiarly weak, or fatigued, — may occur also as a paraplegia, or even as a partial hemiplegia, when, no doubt, the seat of the rheumatic disease is along the spine. In other cases the rheumatic deposit is impinging the theca along large nerve cords, and involving nerve plexuses; and the brachial plexus is, according to my experience, one of the most frequent seats of this disease.

*Treatment.* — So convinced am I that in this malady the nerve cord is somewhere *impinged* by a rheumatic congestion, inflammation, or deposit, that I am in the habit of preceding, alternating, or combining the electric treatment, if not already anticipated, with the iodide of potassium, or the hydrargyri biniodidum and with congress water, for some of the cases. With sponge electrodes, and a smart faradaic current, attack the nerve and muscles involved, and electrify them well for ten, fifteen, or twenty minutes at a sitting. Employ the method of circle and double-circle movements, so as to make the muscles contract; then by team-electrodes; then finish, occasionally, by faradaizing the surface with the metal or wire-brush electrode, if the patient can bear it. Repeat the sitting daily, or every other day. If the primary current is at hand, it is better to alternate it with the secondary at each seance.

In treating rheumatic palsy, the *intensity* of the faradaic current, and the *quantity* of the galvanic current, (if it is employed,) should be in proportion to the degree of the paralysis. We use electricity with more energy upon muscles completely paralyzed, and with less on those which have only a diminution of their power. When we find, in these cases, the electro-muscular

response much diminished, we may conclude there is commencing atrophy. Yet this should not be a reason for discontinuing the electricity, which, on the contrary, according to Becquerel, should be applied with more energy and persistency. In rheumatic palsy, it is not merely the office of electricity to reëstablish the electro-muscular contractions, for often they are still intact; but it is probable that it acts by electrolysis in modifying the muscle tissue and nerve tissue, and that in an imperceptible but decided manner.

To illustrate my method of treating very many cases of rheumatic palsy, here is given the case of Esqr. B., a lawyer of Roxbury, a long time lame from repeated attacks of rheumatism; but about a month previous was exposed to damp, chilly weather, and then suddenly appeared *paralysis* of the right fore-arm, with a fixed, claw-like contraction of the fingers; the flexors and extensors of the arm rigid, and hard, painful, and sore to the handling. I faradaized the skin of the whole affected arm, fore-arm, and hand, for some two or three minutes, by a very smart extra or secondary current, through the *wire brush*, while the spoon-sponge electrode positive was resting higher or lower on the median nerve. Then we applied a primary current of thirty to forty elements, through sponge electrodes, directly over the affected muscles, so as to produce muscle contractions. One seance was devoted to the use of the primary current; the next to the secondary; thus alternating, with deep-shampooing, sometimes using metallic electrodes, sometimes the wire brush as faradaization, and sometimes the spoon-sponge electrodes, with full faradaic current, so as to fully effect good muscular response. Each sitting occupied, probably, some ten or fifteen minutes every day, or alternate days. In a fortnight he was well, and could use his hand for writing.

A great number and variety of cases the author could here introduce showing this affection in the face, and the shoulder, especially of the deltoid muscle; in the neck, and different parts of the back and loins; in the hips, as sciatica, and in the legs and feet; sometimes with contractions, or rigidity of muscles and cords, but frequently as a simple rheumatic palsy. The principle of treatment is the same for all these cases.

*Lame arms* may be due to spinal disease. Dr. Brown-Sequard has shown this most plainly. A patient may come to you complaining of pain in the back, of a pricking sensation in both arms, with some degree of itching, burning; or some subjective sensation, as of alternate cold and heat; or some curious variety of cutaneous eruption. You may find, also, some weakness, or even great paralysis in the arms; jerkings of the arms; likewise a stiffness in some of the muscles, and tenderness under pressure. If you do not know the physiological meaning of all these symptoms, you will be led to suppose that there is some local affection, as rheumatism, perhaps, of both the arms. You will think it very strange, says Brown-Sequard, that you "do not find a description of any such disease in books; yet the explanation of all these phenomena, when read by the light of physiology, is very simple. The lame arms, and other symptoms, depend altogether on an inflammation of the nerves of the arms, at or before their exit from the spine, in the lower cervical region and in the upper dorsal region."

This *neuritis* is usually accompanied by a local spinal meningitis; all the symptoms arise from irritation of the motor and sensitive nerves, and also of the nerves of blood-vessels. If, then, you meet such a case, and see the true character of the injury, you may adopt a certain course of treatment to cure, or, at all events, to greatly mitigate the disease. No electricity can be brought to bear on these cases, in this early stage, with any good results; yet these cases are usually curable. I have seen many of them, and they all recovered except one — that terminated in death.

*The treatment* consists in perfect rest of the arms, and a most active *blistering* of the spine in the region of the disease, preceded by leeches or blood-cupping over the tender spine, and followed up or alternated by dry-cupping about that region. But I repeat, that the principal part of the treatment consists in the repeated applications of blisters to the spine. Internally, the iodide of potassium, and the biniodide hydrargyri, in one fifteenth grain doses, three or four times a day. No electricity, no rubbing the arms or shoulders with liniments, flesh brush, or crash towel; but to wash gently in warm water with soap, to

dry the skin with a soft napkin, and dress warm with cotton-flannel. This may be the origin, or part-cause, of *painful-palsy*, or the inveterate lameness, *which see*.

Persons suffering from various degrees of this affection constitute, to my mind, a class of most interesting and yet deplorable cases. The individual is not sick, and yet there is this insidious process of limb-distorting; and that, perhaps, in the very prime of life, for while the limb or joint is becoming more and more enlarged, contracted, or atrophied, it is also more and more painful and helpless; and if not early arrested, the limb is far worse than lost, because it is useless, painful, and cumbersome. I have often asked myself if of such could have been the "palsied" and the "withered" hands, and feet, and limbs of those who applied, and not in vain, to the kindliest heart that ever pressed our earth — to Christ, the great Physician who but spake, and they were restored. Now, too, under the accumulating blessings of divine Prov-

Fig. 132. A View of all the deep-seated Muscles of the Hip-joint, the Gluteus Magnus being removed.

1. Os Ilium.
2. Os Sacrum.
3. Posterior Sacro-Iliac Ligament.
4. Tuber Ischii.
5. Greater Sacro-Sciatic Ligament.
6. Lesser Sacro-Sciatic Ligament.
7. Trochanter Major.
8. Gluteus Minimus.
9. Pyriformis. From under this Muscle the Great *Sciatic Nerve* makes its exit from the great Sacro-Sciatic Foramen, and in its passage down, it rests upon Figures 10, 11, 12, 13, and 14, and is covered only by the Gluteus Maximus at this point; but farther down is covered in by the Biceps, Semitendinosus, and Semimembranosus.
10. Geminus Superior.
11. Obturator Internus.
12. Geminus Inferior.
13. Quadratus Femoris.
14. Adductor Magnus. The *Electrode* should be placed in the space bounded by 7, 3, 4, 16, and 15, to cover and best reach the Great Sciatic Nerve. For Electro-Puncture, the spot for inserting the insulated *Gold Needle* is at 14.
15. Vastus Externus.
16. Biceps.
17. Gracilis.
18. Semitendinosus.

idence, we have the means of power put into our hands that can reach and restore not a few; for it may well be said, that for these, electro-therapeutics cannot be replaced by any other known remedy, except the miraculous. I have had under electrical treatment a large number of cases of rheumatic paralysis, and many with deposits, contractions, and atrophy; and those of all stages, from the earliest symptoms of numbness, stiffness, and pains, to the older and atrophied cases with pseudo-anchylose and rigid contractions. Of these, my case book shows a very credible amount of restoring good accomplished, and that mainly by the power of Galvanic and Faradaic treatment. But the ratio of cures — of time to produce the cure, (I mean *a rheumatic cure*, which is an approximation to complete restoration, with some liability to recurrence,) — this, in each case, is found to be *nearly* in proportion to the length of time the case had been existing, but precisely in ratio with the degree of tonic contraction and atrophy. But where the wasting is moderate, the anchylosis is still a little flexible, and hence not complete, and the tonic contractions as yet are not great, or even if these all are extreme, but the case is *recent*, then there is the greatest probability that a well-directed and persevering methodic use of electro-therapeutics will solve out the whole difficulty. And even in the older cases of *rheumatic* muscular atrophy and paralysis, the methodic

Fig. 133. A View of the Muscles on the Back of the Thigh.

1. Gluteus Medius.
2. Gluteus Magnus.
3. Fascia Lata covering the Vastus Externus.
4. Long Head of the Biceps.
5. Short Head of the Biceps.
6. Semitendinosus.
7, 7. Semimembranosus.
8. Gracilis.
9. Edge of the Adductor Magnus.
10. Edge of the Sartorius.
11. Popliteal Space.
12. Gastrocnemius.

use of electricity is often of the greatest service in lessening the pains, loosening the rigidity, and warming the part with more vital action, so as to retard or stop this ruinous rheumatic process.

Persons who labor or stand *in cold with damp*, and particularly if they have a rheumatic diathesis, are candidates for this affliction. Hence the washerwoman, fisherman, the ditcher, stall-tender, well-digger, or those who work in cellars and drains, are the most liable to this form of rheumatism. Out of seventy carefully recorded cases, thirty-three were traced to these classes. They were mostly ultimate cases of paraplegia, some complete, some partial; and what is remarkable, the partial cases had, almost to an individual, a previous history of acute sciatica. Some others were affected in the right forearm, wrist, and hand; and this, in one instance, in connection with the affection also in the right lower limb; in another it was in the left limb.

Fig. 134. A View of the Muscles on the Front of the Thigh.

In-door mechanics and seamstresses make another class that very frequently present with local paralysis, and with as well marked evidences of rheumatism; and yet the affection in them is not only paraplegic, but is almost invariably at the same time affecting the *deltoid* and other arm and shoulder muscles, *or these latter exclusively*. In three cases it gradually produced sub-luxation of the head of the humerus. Are these

1. Crest of the Ilium.
2. Its Anterior Superior Spinous Process.
3. Gluteus Medius.
4. Tensor Vaginæ Femoris.
5. Sartorius.
6. Rectus Femoris.
7. Vastus Externus.
8. Vastus Internus.
9. Patella.
10. Iliacus Internus.
11. Psoas Magnus.
12. Pectineus.
13. Adductor Longus.
14. Adductor Magnus.
15. Gracilis.

latter cases of the progressive, wasting palsy, or rheumatic palsy, or are they cases partaking of the character of both these?

Where there is this morbid affection of muscles and joints, I find that a *stabile* strong current led steadily through the *neighboring* muscles also, sometimes on this side and then on that, for a whole minute at a time, and that, for five of the fifteen minutes at each seance, has most decidedly beneficial effects on the contiguous diseased muscles and fascia, and on that joint that is affected and situated below or beyond the site of such procedure. Then let the current be passed from large and soft electrodes, transversely, or rather *obliquely* through the diseased joint from minute to minute, with a recess of only a few seconds between each application.

Fig. 135. A View of the Muscles on the Front of the Leg.

Case. — Mr. C., twenty-five years of age, a lawyer, had a chronic swelling, with stiffness, and at times inflammation of and about the elbow joint, with contractions of the muscles that kept the arm and hand at a right angle, and it was nearly paralyzed. It was tender to touch, smooth, red and somewhat hot, was stiff and painful continually. I placed the elbow on a broad plate electrode, three inches in diameter, that was covered with a soft thin sponge and laid upon the table, upon which his arm rested. This was connected with the *negative* pole, while the *positive* was placed on the outer and upper muscles of the joint, and thus, at first, a scarcely perceptible current of thirty Dan-

1. Tendon of the Quadriceps Femoris.
2. Spine of the Tibia.
3. Tibialis Anticus.
4. Extensor Communis Digitorum.
5. Extensor Proprius Pollicis.
6. Peroneus Tertius.
7. Peroneus Longus.
8. Peroneus Brevis.
9, 9. Borders of the Soleus.
10. Portion of the Gastrocnemius.
11. Extensor Brevis Digitorum.

iell's element was passed through the joint obliquely for five minutes, during which the positive pole was moved from minute to minute, from place to place about the joint, but always on that same side of it. The tension was immediately diminished. I then produced some twitchings of the extensors of the forearm, and then those of the arm muscles, by the current changer. All this had good effects — less red, but joint still hot; omit for three days — heat then less, and much improved, but pain still in the bend of the elbow. This was entirely removed in the course of a few more sittings. In four weeks this treatment most radically cured it, and restored the arm nearly as well as the other.

### *Traumatic Paralysis.*

If all the fibrils of a nerve trunk are destroyed, then the properties of the depending muscles are totally lost. Cases of this kind are entirely incurable and beyond hope, unless a regeneration of nerve and function can be brought about. Of

Fig. 136. A View of the Muscles of the Palm of the Hand.

1. Annular Ligament.
2, 2. Origin and Insertion of the Abductor Pollicis.
3. Opponens Pollicis.
4, 5. Two Bellies of the Flexor Brevis Pollicis.
6. Adductor Pollicis.
7, 7. *Lumbricales*, arising from Tendons of the Flexor Profundus Digitorum.
8. Shows how the Tendon of the Flexor Profundus passes through the Flexor Sublimis.
9. Tendon of the Flexor Longus Pollicis.
10. Abductor Minimi Digiti.
11. Flexor Parvus Minimi Digiti.
12. Pisiform Bone.
13. First Dorsal Interosseous Muscle.

late, this is ascertained to be accomplished in some cases by nature alone, under favorable circumstances. It is believed by Marshall Hall, Duchenne, and Remak, that this can be greatly promoted by a correct use of electricity, not only where nature is in some degree tending to restore a solution of continuity, but also in those unfavorable cases where the nerve is, as it were, profoundly stunned, or changed, and has completely lost its *capability* for action. It has been proved by ample wounds in the living dog, that the nerve is reunited, being entirely new formed through the tissues of the cicatrix.

Dr. Brown-Sequard has established by microscopic research, that in some cases where nerve trunks have received an actual solution of continuity, and the paralysis for the time was complete, yet the nerve fibres, under favorable circumstances, can become entire again, and continuous *through the cicatrix*, so as to communicate with the brain in a normal manner. Dr. Prevost, as also M. Bernard, have made special observations to this end, by destroying a portion of a nerve trunk in a living dog, and then waiting for a perfect healing, and testing for the reëstablished nervous function, then dissecting down upon the spot of previous mutilation, and they find that the nerve fibres are shot across the new growth of the cicatrix so as to completely repair the electro-nervous telegraph, in the order, first of sensation, and then of motion. Thus have we recently learned that a nerve may be cicatrized where it has been divided, and may even be *regenerated* where it has been destroyed; and if aided by favorable circumstances, it will open for itself a new communication when it has been totally destroyed.

First, it must be mentioned, that those paralyses, which Todd, Copeland, Duchenne, and others have called "traumatic," are arranged by Dr. Marshall Hall as "spinal paralysis," and defined by him as that *where the muscles are functionally separated from the spinal cord.* All writers agree that the electro-muscular contractility is diminished in these affections, or even totally lost. Dr. M. Hall assumes that a cerebral paralysis *can* be caused by a disease of the spinal cord; as, for instance,

when the dorsal portion of the cord is injured, the muscles ramified by the nerves that take their origin from that injured portion of the spine present *spinal paralysis;* while the muscles that receive their nerves from any portion of the spine which is below the seat of the injury or lesion, will show us a *cerebral paralysis;* and that because they are merely separated or cut off from the influence of volition, although the affected muscles still remain in their functional relation with the spinal cord. Traumatic paralysis may arise from injury, as severing or *crushing* of the nerve, concussion of joints, or from sprains, or partial luxations.

Paralysis produced by pressure on the axillary plexus of nerves is not of very uncommon occurrence. Frequent examples are seen. Dr. Todd says, "I have seen some cases in which this was produced in the following way: A man gets intoxicated and falls asleep, with his arms, say over the back of a chair; his sleep, under the influence of his potations, is so heavy that he is not roused by any feelings of pain or uneasiness, and when at length he awakes, perhaps at the expiration of some hours, he finds the arm benumbed and paralyzed. It generally happens that the sensibility is restored after a short time, but the palsy of motion continues. Cases of this kind often derive benefit from galvanism; but if the pressure which caused the paralysis has been long continued, then they seldom come to a favorable termination. Nerve tissue is one which *never* regenerates quickly, and seldom completely; so that any great or long-continued lesion of its structure is not likely to be completely removed."

The same high authority gives the following as another example: "This patient is twenty-three years of age; has lived in London, and his right clavicle was broken by an old wall falling upon him. He went to a hospital, (not King's College Hospital,) and the ordinary figure-of-eight bandage was applied. After a time the patient found his right hand and arm were numb; and soon after this he noticed a great loss of power of the extensors of the hand. Notwithstanding these symptoms, the bandage was still allowed to remain, and both the paralysis of

sensation and of muscular motion have continued up to the present time. At present, there are numbness of the hand and arm, and entire loss of power in the extensors of the hand, which are also completely flexed when the arm is raised. All the muscles of the arm have less power than natural."

"This case was treated with galvanism, and the patient left the hospital better; having gained some power in the extensors, and that of the flexors being nearly restored to their healthy state. It was some time, however, before the improvement became so manifest."

*Case of Traumatic Paralysis.*—Jane B., aged twenty-six, had fallen, in February last, down the stairs in a ship's cabin, and struck the top of her head and the back of her neck. She complained, from that time, of unceasing pain in her head, and presented a complete hemiplegia of the muscles of the left side of the face. By testing the case with electro-magnetic currents, we found that when directed to the palsied muscles of the face, they produced almost no contraction of the muscles, although the intensity of the current was so high as to produce all the pain she could possibly bear. This absence of electro-muscular contraction, in some such instances, is valuable as a guide in diagnosis; for here it indicated the case to be a *traumatic* paralysis of the portio dura. Electrical treatments were, therefore, ventured upon, and, in short, the case entirely recovered.

It is to be remembered, that, in cases of traumatic paralysis, this lost electro-excitability of the muscles and their nerve trunks is found more marked *soon* after the occurrence of the lesion. Dr. Duchenne gives an account of a case of questionable paralysis, in which, from ascertaining the loss of the electro-muscular contractility in the left arm and shoulder, and in the absence of other assignable cause, he diagnosticated a traumatic palsy, from a lesion somewhere in the nerve trunks of that arm. He afterwards discovered an exostosis in the neurilemma which compressed certain branches of the cervical and brachial plexus, which he treated by electro-magnetic currents and other remedies, and so brought about a complete cure.

Case of George K., thirteen years of age, son of an offi-

cer stationed at Charlestown navy yard, fell on his left hand in October, 1858, which broke the ulna, and luxated the radius at the wrist joint. The surgeon attempted to set it, but the boy was wild of restraint, and left for friends at a distance; therefore it was put in some kind of starch permanent splint, where it remained for five weeks. When it was opened a large collection of pus was discharged, all the fingers and hand muscles were closely flexed, and the wrist joint became firm in anchylose; total loss of sensation in fingers. This state of things had continued for three months before he came to me, during which time he had employed liniments and hap-hazard electric applications, from time to time, by the advice of many.

When this patient first took the chair for methodic electric treatment, I found all his fingers, hand, and forearm contracted, stiff, and cold, as if hard wood; anchylosis of hand joints; complete paralysis with atrophy of all the muscles of the forearm and hand, as much so, as in the last stages of progressive atrophy; great pain still about the wrist; neither the primary nor the secondary current could produce the least twitch of the muscles. I therefore applied first a current from thirty Daniell's elements, down-running from the upper and inner side of the arm to the palm of the hand, for five or six minutes, intermitting for a few seconds at every minute. Then I used fifty elements through the wrist for one minute, the positive electrode being placed a little above the wrist on its flexion, while the negative was planted on the back of the hand just below the wrist, so as to direct the current through the whole joint, downward and *outward*. Next, I used the same number of elements on the *extensors* of the hand and forearm for a minute, and then finishing the *seance* with *polar alternatives*, for one minute more, on all the extensor muscles of the fingers, hand, and arm. This, he said, had cleared away the pain, and gave to it the *sensation* of life, lightness, and freedom, although it was still utterly helpless. Much in this manner he was treated daily for a week, when some little motion was obtained — to be continued in like manner another week — from that, astonishing improvement. The powers of motion make their appearance successively; first

the adductors, then the abductors, then the bending of the hand, first by flexion, and then extension; but the crooked fingers remain greatly so yet. Left treatment for the present, while absent at Washington.

In about two months after, this patient came again for treatment; had retained the improvement he gained while here before, and there were new motions appearing about all the hand from the thumb to the little finger; patient, in great courage, and better health. I now instituted a series of *local* galvanic baths, immersing only the hand and wrist, and using forty to fifty elements for five minutes, and in the usual manner: this always produced a prickling and warm sensation, particularly in the fingers, but the effects were not so decided and lasting as were produced by directing the current definitely through given nerves and muscles, or muscle groups. Next, the current was directed especially through the *interossei* and *lumbricales* for ten days; still more life-like appearance, and some more freedom of movements in the fingers; but the wrist continues quite stiff; while, on the other hand, the outrageous and persistent pain in the metatarsal bones is banished; and the boy can open the hand so wide that the inner surface of the hand and fingers can be seen, and he is able to take my hand in his and compress it not a little. His friends were then advised to take him to a surgeon, that he might receive surgical aid while under the influence of ether, for the remaining partial anchylose of the wrist joint.

*Concussion or Commotion of Nerves the Cause of Paralysis.* — The following interesting case is to illustrate it. Mr. M., a soldier in company C, 40th N. Y. I., (Mozart regiment,) twenty years of age, and a healthy man. In July, 1863, was wounded in battle, by a rifle ball passing transversely through the neck muscles, from side to side, close over the spine, and near the base of the skull. Two holes were made, one of entrance and the other of exit, leaving sound skin, three inches wide, between them. There was no evidence of injury of bone, or of any large nerve or blood-vessel, but there was sudden and general paralysis. He fell the instant he was hit; was speechless, and for some indefinite time could neither rise to his feet nor move his arms or

his body; was removed from the field the next day, and in a few days could speak. He steadily but moderately improved, while the wound healed kindly, recovering the left arm, and then the legs, to a considerable degree; but the right arm remained more paralyzed, and there grew a general hyperæsthesia of the upper half of his body.

By October he had greatly recovered, under the treatments, so as to be about, but he had no power to move the right shoulder and elbow joint; the wrist and fingers he could move slightly, and had a burning pain in the fingers, which was increased when the hand was cold; left shoulder and arm were much better than right; no burning in left hand, but a numbness. The sensation of touch remained pretty good. Hyperæsthesia less; no wasting. He was brought home, and treated by electricity, through sponge electrodes, over the affected muscles, applied every other day, from the first of September. Just before Thanksgiving he left for a visit away, stating that he felt about as good as new; but I knew he was not quite to his natural estate. One year afterwards he was entirely recovered.

*Reflex palsy* is very frequently a paraplegia, or rather a paralysis of one lower limb; but it may affect any limb or group of muscles. In the history of such a case we may learn that "the outside influence," as Dr. Brown-Sequard has termed it, has *preceded* the palsy; and we also find that the cure of the paralysis readily follows the removal of the said morbid irritation. At least we see that electrical treatment, with other suitable means, can then easily restore the remaining palsy, which could not possibly be accomplished before.

But cases of palsy from shock, and from commotion, must be distinguished from paralysis of reflexion. When a serious wound occurs, and the person survives the first effect, (*shock*,) but is found to have paralysis of a distant limb or part, it is a reflex palsy. He might have died at once from complete palsy or shock, or by death of the blood and extinction of vital force. In severe apoplexy a part of the palsy is doubtless from shock. Shock may thus palsy or kill, as from overwhelming emotions, or from violent convulsions, exhausting labor, lightning stroke,

or grave surgical operation. If there is a contusion, or gunshot wound, *near* a nerve trunk, yet without causing solution of continuity, and there results a paralysis in the depending muscles or limb, and nowhere else, this is termed a palsy from commotion. While the reflex palsy, as we are taught by Dr. Brown-Sequard, is the result of capillary contraction at the nerve roots, which diminishes or cuts off nutriment supply from the fountain of the great nerve centre.

The terrible clash of arms in the southern portion of our country, during the past few years, has sent to us, from the battle fields, numerous examples of reflex paralysis, as well as a great variety of experiences in other nerve injuries. Some cases reported by Drs. Mitchell, Morehouse, and Keen,* acting assistant surgeons U. S. A., give us the following additional examples, showing the relation of the seat of the wound to the part or parts thus paralyzed: —

*First Case.* — The wound involved the scalp and outer table of the upper portion of the left parietal bone. *Result.* — Paralysis of both legs and the right arm, and partial palsy of the left arm. Entirely recovered under treatments, after healing of the wound.

*Second Case.* — The wound involved the muscles of the throat and the hyoid bone. *Result.* — Paralysis of both arms, and of the neck. Not much benefited by electricity, or any other treatment.

*Third Case.* — Wound, by fragment of shell, in the muscles over and external to the right femoral artery. This injury may have caused concussion or commotion of the crural nerves, and thus much traumatic paralysis. *Results.* — Reflex paralysis of the right arm and both legs. He was rapidly relieved by electricity, cold douches, active and passive movements, with iron, quinine, and liberal diet.

*Fourth Case.* — Wound near to or actual injury of the sciatic nerve. *Result.* — Reflected palsy of the right arm. Faradaization has restored it completely.

*Fifth Case.* — A ball wound of the right testicle. *Result.* —

* *Gunshot Wounds and Injury of Nerves*, p. 109.

Paralysis of right anterior tibial muscles, and the peroneus longus. Relieved by faradaization.

*Sixth Case.* — Wounded by fragment of shell on lateral side of left thigh; three cases similar. *Result.* — Paralysis of sensation on the corresponding part of *right* thigh.

*Seventh Case.* — Ball wound, probably involving the crural nerve. *Result.* — Paralysis of motion in right arm, with stinging, smarting, or burning pain in the part paralyzed.

*Eighth Case.* — Ball wound of deltoid muscle. *Result.* — Sensory paralysis, and slight motor paralysis of same arm. In this case there was no evidence that the bone, or any large nerve, was hit by the shot.

In all these cases there was more or less benefit from the electric treatments, and in most of them very great improvement. But in almost every instance some relic of the paralysis remained, even a year or more after the injury. The conclusion is confirmed, by these army surgeons, that in such cases of reflex paralysis from wounds, we may expect rapid improvement up to a certain degree; then, in a majority of cases, there will remain a loss of power, or loss of sensation, or both, but which will be completely recovered in time.

In three of these cases the leg was hit, and the arm of the same side was paralyzed. In three cases the paralysis affected the opposite side of the body, and in one the palsy of touch and of pain was found on the opposite side of the body, symmetrically related to the wounded spot. From these records, therefore, no general law can be deduced to guide us as to where to expect the appearance of reflex palsy from any given wound, should it occur; for it may appear on the same side in one case, and on the opposite side in another case; above the seat of injury in another, or below the wound in another; or both above or below, or on both sides. The probability is, that the state of the patient's health, the condition by fatigue or debility of given parts at the time of receiving the injury, the mental excitement, or the nervous or muscular exhaustion, may have to do with determining the site and degree of palsy thus reflected in the given case.

*Reflex paraplegia* is evidently not owing to disease in the spinal cord; but how shall we know that it is not? We cannot know to a certainty, unless we discover the source of the reflected irritation, which, according to Brown-Sequard, "may start from the most varied region of irritations; on the skin, the mucous or serous membranes, the abdominal or thoracic viscera, as well as of the genital organs, or the trunks of the spinal nerves." But the paralyzed muscles, from this cause, do not become atrophied; their electro-muscular response is but little impaired; the palsy is rarely complete, and only a portion of the muscles badly palsied, while others are very much less so.

*Reflex-nervous affections* of distant parts are sometimes attended not merely with pain, or palsy, but in some instances with some degree of inflammation. The testicle sometimes swells, and becomes tender, during a nephritic attack. The numbness of the thigh, and the drawing up of the scrotum and testicle, so characteristic of an attack of gravel, are analogous phenomena to the pain which affects the shoulders in some hepatic disorders. Irritation of one extremity of a nerve, situated deep internally, and belonging to an organ which is not endowed with a high degree of sensibility, causes sympathetic sensations in the sentient extremities of other branches of the same nerve, or of communicating nerves, superficially and distantly distributed, while there may be but little or no sensation at the point of departure. The prostate gland, the ovary, and the uterus may thus be the fountain head of a legion of various nervous maladies, simple or complicated.

*Paralysis due to shock* must be recognized from other palsy. Shock of the nerves may kill instantly, or paralyze only temporarily; but more generally there is left a lingering partial-palsy, that when understood, and at a proper time treated, may be cured. I know a man who was severely crushed in thorax, between two omnibuses, in Broadway, New York. He instantly fell senseless, showing pallor, and very oppressed respiration; and though somewhat recovered in a few minutes, and more in a few hours, he suffered for a long time from a continued state of vital depression, with sighing, coldness and numbness, feeble

circulation, and great weakness. He is now perfectly recovered, under electric treatments, and is in his primest health. I simply electrified the solar plexus and vital organs, through moist sponge electrodes, in circle treatments with faradaic currents, every other day.

Thus, following accidents and injuries, we may have a traumatic palsy from lesion of nerve, or a reflex palsy from an induced state of the nerve centre or root; or a paralysis from simple shock; or a still more constitutional result, as manifested in a changed action of the mind and will; or, as sometimes results, in a permanent modification of vital force and of functional action of organs of animal life.

Between the temporary palsy of the whole range of nerve centres, produced by shock, and their diminished supply of blood nutriment, owing to the simultaneously induced cardiac feebleness, we can see cause enough to account for the phenomena of reflex palsy; but it may not be so clear as regards reflex palsy from slower and chronic causes. In most of the cases observed by our army surgeons, from sabre cuts, shell, or gunshot wounds, the constitutional effects were instant and severe. And there are other symptoms that we can thus account for, by supposing, further, that the shock induced some profound central lesion of a morbid irritative character; as, for instance, the early and persistent suffering from *stinging*, *smarting*, and *burning pains*, not in the wound, but in the distant part that is reflectedly paralyzed. But these morbid or referred sensations in the palsied parts occur only in a few of the cases, and are usually recovered from sooner and more completely than the paralysis.

*Diphtheritic paralysis* is not a part of the attack of diphtheria, but is a distinct after affair; a sequel of it. The time of the appearance of this palsy — i. e., after the patient has apparently recovered from diphtheria—is quite variable. Usually the patient fully recovers, apparently, and seems quite well. In some patients I have seen, however, there appeared scarcely any appreciable interval between the primary affection and the attending or resulting paralysis. More generally we find the loss of muscular power has come on gradually during convalescence, or

even still later. From about two to ten weeks is the time to look out for it, and therefore it is not safe to pronounce the patient cured of diphtheria until a month or two have elapsed. It may be local, as in the palate, or the pharynx, or involving also the throat muscles; or it may be quite general, affecting mostly the supporting muscles of the head, the nates, and thigh muscles, and those of the arms also, but in less degree.

This palsy more generally affects the throat only; producing true aphonia, and a general nerve and muscle debility. Where there is loss of power of motion in the limbs, it is usually preceded by numbness, and perhaps formicans. But these patients will more frequently present with loss or diminution of power over the vocal organs, and a difficulty of deglutition. The act of swallowing food is not only difficult, but painful, and portions of the food will sometimes find their way out of the nose, owing to the palsy of the palate.

In others, the pectoral or abdominal muscles lose size, and solidity, and tone. The bowels and sphincter of the bladder are partially paralyzed, and the thigh muscles especially will, in very many cases, show, by their flabbiness and weakness, the extending blight; and there is often to be seen a diminished and pendulous condition of the soft palate, with irregular muscular action about the eyes; and at the same time the patient appearing pretty well, and eating well.

Dr. Putnam, of this city, sent a young man, Mr. A. T. L., to me for aid by electricity, in a diphtheritic paralysis, general, but incomplete, following the primary attack (which was only moderate) several weeks thereafter. His legs were already so thin and feeble that he could scarcely walk, yet it was but about four weeks since it began to be manifested. His countenance was pale, his whole appearance feeble and unpromising. The paralysis was slowly but gradually increasing, with a stiffness in the flexor muscles, and attended with pains. All kinds of treatment here were unavailing.

Dr. Greenow says, "Nerve affections following diphtheria consist chiefly of impaired, perverted, or excessive sensibility, together with a more or less complete paralysis of the muscles of

the fauces, pharynx, tongue, lips, extremities, trunk, and neck, the frequency of the occurrence of these symptoms in the several sets of muscles being nearly in the order named." Dr. Metcalf, of New York, says the eyes are not unfrequently also affected; and this accords with my own later observation, particularly in nervous, delicate subjects.

The rule laid down by some authors is, that the probability, extent, and severity of the now and then following paralysis, are in direct ratio to the intensity of the primary attack of diphtheria; but this, I must insist, is not so. We may look out for it after the slighter attacks, fully as frequently, if not more so, as after the more severe.

My own little boy, about seven years old, at the time attending the Chauncy Hall school, was *diphtheritic* in the month of March last, but not sick enough to take to his bed, nor even to keep him from school; only as I refused to let him go. He ate well, but his throat was sore, the tonsils enlarged and painful; his breath had a fresh smell, and there was a peculiarly sick smell in his hair; and he seemed for two or three weeks drooping and quite debilitated, and disinclined to play so freely. He snored nights, and perspired profusely while sleeping, in spite of all arrangement of covering. But no well-developed symptoms of diphtheria ever appeared, (perhaps owing to the prompt treatment, by a cathartic, tonics, nourishing food, and the open air, with vigilant care,) and yet, after five weeks, there came the much dreaded *sequel*. He then showed a rapidly diminishing muscular tone, generally; but more particularly in the throat. There was an incessant hacking or cough and efforts at swallowing. The child would play some, and could see large letters, at a distance, plainly; and yet could scarcely see the letters in his book to read. The two scapulas loosened and tilted out from the ribs, the pectoral and thigh muscles *wasted*, and the muscles of his arms were soft and weak. He lost relish for very many dishes, of which he was previously very fond. But his diminished sight caused me the greatest anxiety; not having seen so marked a case of it before. The ciliary muscles, in this case, seemed to be decidedly paralyzed. All this was manifest during

a month's time; and now, nearly a year after, though well recovered, perfectly recovered, in every other way, there is difficulty in reading, and in adjusting the focus of the eyes. Otherwise he is in prosperous health.

The history of those cases which have occurred in the Children's Hospital, in Paris, during the year 1861, has been carefully investigated by M. Rogers, to ascertain the relation of palsy to this primary, terrible affection. Among the two hundred and ten cases thus observed, he found that thirty-one cases of paralysis appeared as a sequel; that is, one in about every seven of the number remaining under observation. But many of the patients die early, and others are removed from the hospital before the period for paralysis. He thinks that nearly one fourth of all attacks are followed by paralysis, less or more. In these children the palsy always began at the pharynx and soft palate; in two out of every ten cases, the paralysis progressively extended so far as to involve the lower extremities.

I should state that the fauces and palate will, in some cases, even during the process of recovery from paralysis, take on hyperæsthesia; and this exalted sensibility may also appear over other affected parts, in any part of the body or limbs. Or the other extreme, anæsthesia, may attend the partial palsy of motion, and show most usually in the throat. But the most dangerous of all varieties in diphtheritic palsy is that which affects the heart. The pulse and heart-beats will then grow more and more feeble and unfrequent, until they finally cease to be perceptible. In some of these cases death has occurred from instantaneous cessation of the heart's action. For this reason, such cases should be guarded against putting forth any great exertion, until the force and frequency of the heart and pulse will render it safe. Finally, this affection is, in a word, insidious, progressive, and not regular in its accession, order, or duration. Some cases are very readily and rapidly restored; others, more slowly; while others inevitably die. Usually this palsy is slow, protracted, and recoverable; but in some it is sudden in its termination and unavoidably fatal.

*Treatment.* — My own experience in the treatment of these

cases of diphtheritic palsy, justifies me in speaking in most encouraging terms of the effects of electricity, (when directed to the affected muscles, and also at every seance for reflex effect,) and the almost certainty of recovery if taken in time. No brain or spinal lesion has ever been discovered in those that die of it, only paleness and softness; therefore the impoverishment of the blood, or general blight of the finer nerves and tissues, by the diphtheritic poison, is a fair field for the vivifying and chemical action of electricity; as also to prevent the ultimate deterioration of the great centres.

The faradaic *extra* current, if beginning very gently, is best, applied through large sponge electrodes, by slow bathing movements over the affected parts for five or ten minutes. Then plant the electrodes at some distance from each other, say six inches to a foot or more apart, with the negative nearest the head, and so run *an up-running* current for some three to five minutes more for a reflex effect; then finish the seance with a very smart induced current, by faradaizing through a metallic tip, or the wire brush, in painting motions, only for a minute or so. Let this be repeated daily, or every other day, or twice a week, according to the urgency of the case. As soon as the *progressive* action of the disease is stopped, and the case shows improvement, the sittings may be less frequent. I prescribe, also, in the smallest doses, *formulæ* 6 and 9, or 10; 19 or 29; and aid all by deep-shampooing, and mellowing, and passive motions.

*Flesh-worm Palsy.* — Among a pork-eating people, this *pork-palsy* might be a frightful subject, and, indeed, it ought to be. Every morsel of pork flesh should be cooked well-done. That is, whether ham, bacon, sausages, chops, or any sort of fresh pork meat, it should be thoroughly cooked, or else never eaten. It is absolutely dangerous, to say nothing of the aggravated humors, and other unhealthiness, arising from eating raw or rare fresh pork. It is now well known, that the hideous *tape-worm*, that so frequently occurs, and the "*flesh-worm disease*," the most frightful of all affections to which the human body is liable, find their way into the human system from eating pork flesh

that contains the living parasites, or the embryo of them. *Three* of the most general articles of consumption among our common people, are, doubtless, most damaging to them, viz., *rum*, *tobacco*, and *pork* in a fresh state. Lard, and well-cured salt pork, are quite other articles; they may be as sweet and wholesome as butter or beef, when properly used.

The flesh-worm from pork is not to be seen with the naked eye, but is hid in the meat encapsuled; once in the human stomach, the calcareous capsule is digested with the flesh, and the *trichina* is set free; which immediately develops and multiplies at a prodigious rate, and commences its work of vivisection and destruction. This consists, in the first instance, in attempts to pierce the walls of the alimentary canal, attended with bowel troubles, inflammations, formation of pus in the intestines, and sometimes bloody stools. If a very little of the meat only is eaten, or from other reasons, in some cases, there is only pain and uneasiness in the bowels at first; but there are in all cases, sooner or later, wasting, prostration, speedy paralysis, and finally slow death.

The first illness from these horrible and "*mighty little*" worms, seems to indicate a peritonitis, then pneumonia, and next muscular rheumatism, with great soreness and stiffness, then paralysis of the intercostal muscles, and muscles in front of the neck, and then involving also the abdominal muscles, always seeking the striated muscles. This worm may be *seen* sometimes in those affected with them, when well developed under the thin mucous membrane covering the under side of the tongue. The meat of sausages has been examined by microscope, and found to be swarming with encapsulated *trichinæ*. They were then sought for in the muscles of the sick men, and actually found; and some bits of them were extracted from the living flesh. Unsuspected, how often cases of obscure and insidious disease of this nature might prove fatal, and never be questioned? Were these the worms that destroyed Herod? "He was eaten of worms, and gave up the ghost." Acts xii. 23. To this day there is no known remedy; unless it be *naphtha*, in 10 or 20 drop doses taken in sirup.

### *Lead Palsy.*

*Lead paralysis* is an accident most likely to occur in persons working in *lead* or its compounds, as painters, compositors, plumbers, lead-pipe workmen, and the hands in white-lead manufactories. It may and does occur frequently from drinking *made*, or *adulterated*, liquors or wines, fixed beer, or from taking quack medicines, and clandestine prescriptions. Thus some drink the saturnine poison, others inhale it, while others are affected by handling it. An impure, or rather an impregnated water, as with acid, iron, or salts, if conveyed through leaden pipes, may also cause lead palsy. I believe, in fact, that a *taint*, or *predisposing state*, may be not unfrequently imbibed with drinking water that has lain in, or flowed through, lead service pipes.

When the blood of a person has become to any great degree contaminated with lead, then there are produced various abnormal symptoms, and these are usually in the following order: first colic, next cramps, then neuralgia or amaurosis, and then the "*dropping of the wrist.*" These are the first prominent symptoms of lead palsy. The extensor *muscles* of the upper extremity, and most generally those only of the right forearm, are most liable to show it first; and these same finally suffer the most wasting. All the joints of the fingers are not equally affected. It is the first phalanges that cannot be extended; while the power of motion in the two last phalanges of the same fingers is not impaired. This is because the *interossei* muscles are very rarely affected by lead. The paralysis soon extends up the arm, and we find even the *triceps* and the *deltoid* suffering the loss of substance and power. The electro-muscular contractility is then much diminished, and in a short time is utterly lost. After that occurs, wasting goes on rapidly.

But this ruinous result should be avoided, as indeed it can be, by an early and efficient resort to electro-therapeutics, as this is the most potent remedy for lead palsy now known to the healing art. We notice that M. Tauquerel-des-Planches reports that out of one hundred and thirteen cases of lead palsy, ninety-three cases had this palsy in the arms, fourteen in the lower

extremities, and six as extensive or general paralysis. All authorities agree that electricity should be resorted to in cases of this kind, in connection with the internal use of the iodide of potassium, and even if late, as where there is no response by contraction of the affected muscles to the electric stimulus, and where the size of the muscles is already considerably diminished.

Fig. 137. A View of the Muscles on the Back of the Forearm, (Extensors.)

*Case of Lead Palsy — Electro-Excitability of the Muscles gone*, (taken from case-book.) — William Kittridge, of New York, had for several years worked in the Brooklyn White Lead Works. He is thirty-eight years of age. He has had repeated attacks of lead colic, for which he was always promptly attended by the best of medical skill. As he was an important workman about the works, he was always amply cared for. He is sent on to me by his employers. He does not stand erect; has dropping of both the hands, and decidedly stoops as he attempts to walk. He appears dejected in countenance, voice, and movements. His pulse is sixty; bowels are obstinately constipated. When the hand is placed on the abdomen the parieties appear contracted and hard. A blue line is distinctly visible near the edges of the gums, but about only *some* of the teeth. The

1. Lower Portion of the Biceps Flexor.
2. Part of the Brachialis Internus.
3. Lower Part of the Triceps Extensor.
4. Supinator Radii Longus.
5. Extensor Carpi Radialis Longior.
6. Extensor Carpi Radialis Brevior.
7. Tendinous Insertion of these Two Muscles.
8. Extensor Communis Digitorum.
9. Portion of the Extensor Communis Digitorum, called the Auricularis.
10. Extensor Carpi Ulnaris.
11. Anconeus.
12. Portion of the Flexor Carpi Ulnaris.
13. Extensor Minor Pollicis. The Muscle nearest the Figure is the Extensor Ossis Metacarpi Pollicis.
14. Extensor Major Pollicis.
15. Posterior Annular Ligament. The distribution of the Tendons of the Extensor Communis is seen on the Backs of the Fingers.

whole right arm appears to be nearly paralyzed, even to the shoulder, although he can hold a cane in his hand. If the arm and hand are rested on the table so as to extend the first phalanges, and thus allow the second and third phalanges to extend over the edge of the table, he has all needful power to move, extend, and contract the second and third phalanges; and this is evidence that the *interossei* and *lumbricales* have not been involved. In the left, this is in less degree. The voluntary lifting of the arm from the table, he finds, is difficult; but the extending it out horizontally is quite impossible. The back of the forearm is fairly concaved from the wasting of the extensors. The flexors of the arm are not in the least affected, but the deltoid is diminished certainly one half. Upon his taking the operating chair and receiving the electrodes of one-inch metal balls covered with wet wash-leather, the one being placed over the nerve *ulnaris* and the other over the wasted muscles, no kind of contraction could be produced by the strongest electro-magnetic currents. But he continued to receive electric treatments twice a day for twelve days, when it was noticed that not only the withered *deltoid* muscle showed some excitability, but also the wasted extensors of the forearm began to swell with fluids, became warmer, and showed some signs of muscle fibre contractions. The treatments from this time were had daily for ten days more, accompanied with shampooing and automatic movements while at home; and these latter were also repeated several times a day. The patient received from this time also at every *seance* the primary current of galvanic electricity, from twenty to thirty Daniell's elements, as part of the treatment; using the Faradaic currents first, and then the Galvanic, — in all not more than from five to ten minutes at each *seance*. Not only the *labile* method, but also *metallic reversings* and *polar alternations* were employed, so as to produce muscular contractions if possible, and to cause greater capillary circulations. At the end of these ten days it was very noticeable that the warmth, growth, and strength of the palsied and wasted muscles of both arms had returned faster than in the twenty days previous; and, to my mind, the

alternate electricities produced from second to second, or every five seconds, had done much, by reflex action, towards restoring the muscles to an obedience of the will. The electrical treatments were daily repeated for some three weeks more, when Mr. Kittridge returned home, and, as he says, in writing to me since, "as good as new."

*Rule.* — In lead palsy we may always expect to find a more or less *diminution* or *loss* of electro-muscular contraction; therefore, in doubtful cases, where the muscles of a paralytic limb simulates lead palsy, yet contracts promptly or decidedly as response to the electro-magnetic or magneto-electric current,

Fig. 138. A View of the Muscles and Tendons on the Back of the Hand.

1. Lower Portion of the Extensor Communis Digitorum.
2. Extensor Minor Pollicis Manus.
3. Tendons of the Extensor Communis.
4. Extensor Major Pollicis.
5. The Ulna.
6. Tendon of the Auricularis.
7. Extensor Carpi Ulnaris Tendon.
8. Posterior Carpal Ligament.
9. Insertion of the Extensor Carpi Ulnaris into the Metacarpal Bone of the Little Finger.
10. Adductor Minimi Digiti.
11. Middle Tendon of the Extensor Communis.
12. Tendon of the Ring Finger.
13. Prior Annularis.
14. Flexor Parvus Minimi Digiti Manus.
15. Interosseus Digiti Auricularis.
16, 16, 16. Arrangement of the Extensor Communis Tendons at the Phalangial Articulations.
17. Points to the *Interossei* Muscles on the Back of the Hand.
18. Insertions of the Extensor Communis.
19. Cross Slips connecting the different Tendons of the Extensor Communis.
20. Tendon of the Indicator.
21. Prior Indicis.
22. Insertion of the Extensor Major Pollicis.
23. Abductor Indicis Manus.
24. Insertion of the Extensor Carpi Radialis Longior.
25. Extensor Minor Pollicis Tendon.
26. Extensor Major Pollicis Tendon.
27. Insertion of the Tendon of the Extensor Carpi Radialis Brevior.

we may fairly conclude that in such a case *lead is not* the cause of the attack. The electric current is here the only reliable diagnostic test.

While we must admit, it is true, that the deeper strata of muscles, which are covered by the superficial muscles, will not exhibit electro-muscular contraction from *direct* Faradaization, yet, as atrophy diminishes the superficial muscles earliest and mostly, we have been thus helped to the knowledge of the physiological function of every muscle in the living body. I may mention, in this connection, as one of the most remarkable facts quoted by recent writers, viz., it is found that the muscle *extensor communis digitorum* has no influence whatever on the extension of the second and third phalanges, as generally thought, but only on the first; that it is in fact the small *interossei* that extend the second and third phalanges, while the *lumbricales* bend the first phalanx; that the *flexor sublimis* and *profundus* muscles bend the second and third phalanges, but not the first. Pathological facts have also demonstrated this, as in cases of lead palsy and muscular atrophy. We find in cases of lead palsy that the *extensor digitorum* situated on the back of the forearm is palsied, and perhaps atrophied also; but the affection does not reach the *lumbricales* and *interossei*. In lead palsy, therefore, the capability of extending the second and third phalanges remains normal; it is only the first set of phalanges that cannot be extended, and this gives the characteristic "*dropped hand*." On the contrary, if there is paralysis, and perhaps atrophy too, of the *interossei* and *lumbricales*, while the *extensor digitorum* is not at all paralyzed, as in "wasting palsy," or after some severe sickness, then the fingers present the appearance of *claws;* the hand is extremely lean, and the interosseous spaces are deeply hollowed out. Here we see the first phalanges *can be* extended and contracted at will; but the second and third phalanges are *constantly* bent. This is the reverse of what takes place in lead-palsy, and is a diagnostic sign between wasting-palsy and lead-palsy.

The pathology of lead palsy is not complete. Perceptible changes in the peripheral or central nerves are not definitely

seen, though sought for by Drs. Andeall, Gendria, and Tanquerel; but Dr. Todd found evidences in the cord and brain of imperfect and depraved nutrition, attended with marks of chronic irritation of the membranes, such as are found from intemperance; as ill-nourished, pale and soft brain, convolutions wasted, the sulci between them wide, and sometimes patches of white softening in the hemispheres. But these appearances occur only in the latter stages, as after lead epilepsy. Late writers, as Grisolle, Solon, and others, speak of a yellowish discoloration, and atrophy of the brain. The ulnar and radial nerves have been found atrophied, as also the heart.

On dissection, the paralyzed muscles are found altered in texture and color. The muscular fibres lose their normal form, become atrophied, and appear of an azure color; are friable and shrivelled in their molecular structure, and by chemical test show the presence of lead. Drs. Orfila, Tiedman, and Deverge have lately shown that in subjects who have died from lead poisoning, lead is found in the brain, muscles, viscera, and especially in the blood.

*Colica pictonum*, or painters' colic, as is now well known, is due to the absorption of lead. It is the result of *slow* poisoning, of the first degree, and has a peculiar name for its distinctive characteristics, and has a very well-defined group of symptoms. Of its earliest history, in the individual case, we usually learn nothing, except the occasional occurrence of constipation, with colicky pains, and that his business perhaps might expose him to lead poison. The first considerable attack is usually a simple colic, with constipation, and a coated tongue; the pulse is natural; the abdomen in some cases is retracted, while in others it is full and tympanitic, but not tense or tender, nor are the colic pains sharp or darting, as in bilious colic, but are tearing, grinding pains, which produce cool goose-flesh skin and prostration. Pressure over the bowels rather relieves, and motion does not aggravate it; therefore, instead of lying in bed, with knees drawn up, as in other colic, the patient rolls and tosses about. If much lead is absorbed, we may find a *blue line* along the edges of the gums where they fit to the teeth; and this is conclusive.

*For lead colic*, early in the disease, use electricity through large, moist sponge electrodes, and a *very brisk* current, applied by slow circle and double-circle, and hazing movements over and about the umbilicus, as if bathing the abdomen, and to be continued until relieved. Repeat it thus as often as the cramp in the viscus returns, and until there is decided relief; the patient to be kept dry and warm; to sedulously avoid liquors, tobacco, and every enervating influence. The bowels must be kept free, the stomach light and easy, and the mind easy.

The effects of lead poison usually are well marked, and may be known as soon as seen; but there are some cases of lead palsy that may require more nice investigation to discover a portion or the whole of their true character. In fact we are taught that *a very slow* poisoning by lead, arsenic, mercury, and other poisonous agents, can produce quite a modified set of symptoms from those usually manifested after the more decided action of one or more of these, or other powerful drugs. Indeed, we can profitably arrange these cases in three classes for study and remembrance.

1. Where large doses are taken, so as to produce marked symptoms, and perhaps so as to endanger life at once.

2. Where the quantity taken is less, but more continuous, or is absorbed through the skin — taken by absorption.

3. Where the poison is infinitesimal and long continued, as in water or food, or as particles in the air, and taken by inhalation, — which in itself, perhaps, would not be sufficient to produce disease in a vigorous, well person, but acting on an already enfeebled system; that is, where there is debility, or debility with irritability, or in that more delicate organization that we term impressibility and susceptibility, — the poisonous influence is manifest.

For instance, if arsenic is taken in small doses by the mouth, after a while there is produced a bloating of the face and about the eyes, together with a general tonic effect to a relaxed system; but if taken by inhalation, even in infinitely smaller doses, as from arsenic wall-paper, its poisonous effects are very different; now we get a peculiar chronic inflammation of the mucous surfaces in the fauces, the eyes, and gastro-enteric irritation, with

a peculiar dyspepsia; as also trembling of the limbs, with a loss or consumption of the flesh and strength — *a general decline*. This entirely different effect, from different mode and dose of the same drug, is true of many other and more simple substances, as ipecac, rhubarb, and opium. If ipecacuanha or rhubarb is given in grain doses, or a fraction of a grain, and often repeated for some time, there is brought about a decided specific action; if given in drachm doses, there is now produced not simply an increased action of the same kind, but quite a modified result, as unlike the first as if another article in kind had been given in its place. Hence we must be on the lookout for very modified symptoms from the poisonous effects of lead, and other poisons, according to the dose or doses, the method of taking it, the length of time, and, perhaps more than all, the condition of the patient's system at the time of taking it. We see, also, that a slow poison may be acting on a whole family, and yet none, or only one or two of the feebler ones, will show it.

Case of A. G., aged thirty-two. Had a family; was a workman in a wholesale drug and paint store. Said he had never been sick, but the past six months had somehow grown poor and weak all the time. His appearance was cachectic and anæmic, his countenance haggard and melancholic, pulse small, and without the usual vim. There was no wrist-dropping, but a general appearance of decline and dejection. On undressing his shoulders and arms, the skin was dingy in color, and appeared goose-fleshy; the muscles generally shrunken and soft; had gradually grown feeble and poor in flesh since last spring, but latterly more so; all the while gradually losing the power and control of the muscles, until now not able to do any thing. He could not in the least raise his arms out laterally, but could make out to get them up in front to his mouth; could walk a little by being supported, but his legs trembled and his knees inclined together, and he walked and sat parrot-toed. He was emaciated generally, in body and limbs, but in some muscles and groups of muscles more than elsewhere. The deltoid muscle, the supra and infra-spinata were badly atrophied; the biceps and triceps of the arms were almost gone; the extensors and flexors of the fore-arm were flaccid and soft, but not so wasted; in like condition were

the pectoralis and latissimus dorsi, and the muscles of the thumb and hand. The trapezius, the spinal and lumbar muscles, as well as the muscles of the thighs, were soft and wasted; the glutei and adductors of the left side most so, and the testicle of that side hung very low; but I satisfied myself that it was not tabes dorsalis, nor yet Cruvatier's wasting palsy. Suspecting a very slow lead-poisoning, that of the *third degree*, his gums were examined, when a faint, dull, blue line could be seen at the edge of the gum around several of his teeth; the gums and teeth, tongue, breath, and all his mouth, were filthy and unhealthy.

*Treatment.*— At once concluding it to be mainly a *slow* lead poison, I ventured this diagnosis, and on this based my course for treatment; and in four months it was entirely successful. In the majority of these anæmic and atonic cases, iodine, iron, quinine, and strychnine are strongly indicated. The anti-paralytic properties of the latter article should lead us to make it an adjuvant, in one twentieth or even one fifteenth of a grain dose, given once, twice, or three times a day, with whatever other medicine the individual case may require, keeping the patient at all times warm. Electricity in *moderate strength*, for electrifying the muscles, also for faradaizing the skin over delinquent, sick, soft muscles, for ten or fifteen minutes a day, is an heroic aid in the treatment of such cases; indeed, this is to be reckoned as our sheet anchor. It should be alternated with deep-shampooing. Warm sulphur baths, using a quarter pound of sulphite of potassium, or soda, to each bath, which is to be at 90°, while the temperature of the room is at 80°, twice a week. In the earlier stages of the affection, or wherever lead is suspected as still being in the system, the iodide of potassium should be freely given to eliminate it; afterwards, iron, strychnine, and bark.

Case of H. M., aged fifty-three, a machinist. Is employed in wire work for iron fence; has been gradually losing the use of his arms and hands for several months, and now, upon application for electric treatment, is quite helpless in his arms. The hands are fairly dropped at the wrist joint, with complete paralysis of the extensor muscles, which are badly atrophied in the right arm, but less so in the left. There is not the faintest

muscle contraction under the strongest faradaic current; the arms and hands are of a purple color, skin dry, and in places show goose-flesh. There can be but little doubt that this paralysis is the result of slow poisoning by lead, in the *second degree*, as he had previously suffered from neuralgic pains, though no sort of clew to the introduction of lead into his system could be had; test of his urine negative. His complexion is pallid and dingy, the gums and teeth are in a bad state, the tongue coated, and breath foul, but no blue line along the edge of his gums. The result of treatment confirmed the diagnosis.

*Treatment.* — A galvanic current applied from the elbow to the back of the wrist, through moist sponge electrodes, from thirty Daniell's, reversed every quarter minute, for five minutes; followed by smart faradaization of the skin and muscles of the whole fore-arm and hand, alternated with deep-shampooing and mellowing, and to be repeated daily. Sulphite of potassium, quarter of a pound, dissolved in warm bath of 90°, and to lie in it for twenty minutes every three or four days; iodide of potassium in solution; and pills of quinine one grain, strychnia one twentieth of a grain, to be taken three times a day. The sulphur baths to be repeated four times. By degrees faint contractions could be seen now and then in certain places, more and more plainly; the arm growing plumper and more natural in color, and in texture of skin. Three months after this treatment was commenced, improvement being slow, this man had quite recovered the use of the arms and hands, and returned to the shop, being the foreman. If the physician has no primary battery at hand, the induced current must do; but if he has the *extra* current arrangement in his faradaic apparatus, it can here be employed as if it were the true primary current.

*Case.* — Mr. M. worked in a pottery in Chelsea, doing the enamelling or glazing. He appeared pale, cadaverous, and palsied; says he first felt severe pains in the abdomen, epigastrium, and loins, some three months before. This soon increased to colic, and this was finally attended with repeated vomiting, to such degree that he said he ejected all his food. His strength now diminished rapidly, so that he could not stand. Has never been much constipated, but his gums are swollen, the margin

about the teeth showing a line of well-marked dirty blue. His eyes were dim, and his skin and hair were dry and unhealthy looking. Has no desire for food, but rather is disgusted by it; the abdomen was not contracted, but extremely painful, particularly about the umbilicus. He was unable to open his hands, and they trembled continually, while the sensibility in both hands and feet was decidedly diminished.

*Treatment.* — He was treated by daily applications for electrifying the affected muscles; the sulphur bath twice a week; while iodide of potassium was alternated with pills of iron, quinine, and strychnia. He improved rapidly, and in four or five months was quite recovered and at work again.

### *Wall-Paper Poison.*

This is, we believe, a prodigious source of ill health, and doubtless frequently *helps on* some of the graver nervous affections, and even the "*decline.*" The poison from bright or velvety green paper-hangings (with green ground, or *merely green vines or figures*) is more frequently an *arsenic poison*, (the dark English green, and the blue, are more likely an oxide of arsenic and copper; the bright yellow and white are of lead, and the olive green from arsenic, cobalt, &c.,) while the poison from water service pipes we know is a *lead poison.* But mark! these two classes of very deleterious agents — in effect, "*slow poisons*" — are actually and perpetually at work, contaminating almost every respectable dwelling in all our large cities, as well as the majority of country residences and village homes. Arsenic acts as an *irritant* poison, while lead acts as a *sedative* poison; but from the *ultimate* effects of both (or either) there may occur pains, palsies, weaknesses, and emaciation. But physiology shows us that there is a ceaseless depurating and *repairing force* going on in the human organism during health, which indeed is a very law of our being. Therefore, while the poison is minute on the one hand, and, at the same time, the health of the individual is vigorous, nothing of it is perceptible to us, although some of the organs may already feel the insidious influence. Now, if the vitality of any member of the fam-

ily become lowered, from any cause, and consequently the depurating and repairing force is enfeebled or nil, and particularly if, at the same time, the minute particles or portions of this poison be somewhat increased, then it is that the nervous system gives way, and finally becomes deranged and diseased. The more immediate effects and consequences of extremely minute particles of arsenic floating in the air, or as dust, in the rooms of a house, it must be known, *do not act the same* as when arsenic is properly prepared and taken as a medicine, but appear to be manifested by a weakness, or a kind of irritation of the eyes and throat. Dr. Jeffries recently read a very interesting paper on this subject before the Suffolk District Medical Society, showing that there may also be *sudden* and unaccountable attacks of *dyspepsia*, and other gastric derangement. Next, we find there are pains, partial palsy, loss of flesh and strength, and the case may possibly be mistaken for that of consumption, and then the end is inevitable.

As a member of the medical profession, peculiarly positioned for seeing and knowing these direful consequences of *house poison*, I feel it a *duty* thus to plainly speak and urge the information of the public mind, and, if possible, to arouse the attention of the public authorities when it becomes more generally known.

*The Electro-chemical Remedy for Poisoning by Corrosive Sublimate.* — A rejected lover, at the time a visitor in Baltimore, Maryland, committed suicide by taking a large dose of corrosive chloride of mercury. The case fell into the hands of Dr. Thomas H. Buckler, who, after using every antidote and means up to that time supposed to be useful in such cases, saw his patient die in great agony. This made so great an impression on the doctor's mind, that he immediately commenced experiments on animals to see what would expel or neutralize this dreadful poison. It seems he was already aware of the well-known "*galvanic test*" for mercury; and it finally occurred to him to magnify this into an antidote; for said he, as reported, "If the chloride in solution, being placed on a bright gold surface, undergoes decomposition, there is no reason why gold and iron in the form of powders, exposing great surface, should not

also separate chlorine and mercury in combination, even if in the living stomach. Moreover, the elements would be instantly appropriated by the antidotal agents; the mercury attaching to the negative electrode, i. e., the gold; while the chlorine unites with the iron, i. e., here the positive pole; and thus for a highly dynamic substance we substitute a comparatively inert amalgam of gold and a harmless chloride of iron."

Accordingly there were introduced large doses of corrosive sublimate into the stomachs of dogs and pigs, and then, after various intervals, there were passed given quantities of gold leaf and iron filings into the stomachs of some of the animals so poisoned, and the effects were watched. Those that took the gold and iron powder in a given quantity, and within a given time, recovered; the others, of course, died.

Now, these experiments have been carried into actual practice in the human subject, and with complete success. Dr. Christopher Johnson reports a case, so treated, in the American Journal of Medical Sciences of 1864, from which we condense the following particulars: —

*Case.* — "A gentleman of this city, being disturbed in mind, procured two drachms of corrosive sublimate from an apothecary, assigning as a reason his intention of destroying rats; mixed two thirds of it with whiskey and water, and swallowed the whole at a draught, leaving nothing in the tumbler. In about ten minutes, his wife, hearing vomiting in his chamber, went in, and found her husband in most agonizing emesis. A word, and the fatal paper, satisfied her as to the danger, and she instantly sent for medical aid; and in the mean time gave him 'milk and the white of eggs.' In five minutes more, we were by his bedside. The new galvanic antidote being prominent in mind, we sent in haste for two drachms of iron bi-hydrogen, and a book of gold leaf. The patient continued to vomit violently and unremittingly. After sturdy efforts, small quantities of greenish mucus, streaked with blood, were thrown up, while the face was much congested, the body cold, and the whole surface bedewed with sweat. In about twenty-five minutes from the time of his taking the poison, a bolus was prepared by dust-

ing the surface of a leaf of gold with the powder of iron, and over this another leaf and iron, and so on until about one half of the gold was used, and the mass was loosely rolled into a ball.

"Before giving this to him, however, we administered warm water to effect the removal of mucus, albumen, and milk, should any of these be remaining in the stomach. Instant emesis followed. The bolus was now readily taken into the stomach, aided by a little water, for by this time the poisoned man regretted his act, and wished very decidedly to escape from speedy death. For five minutes there was a calm, during which we made another bolus of the remaining gold and iron. Vomiting now recurred, but with less violence, and the matters ejected were tinged with yellow or light brown, and contained particles of gold leaf. The second bolus was soon given, after which vomiting soon ceased entirely; although at intervals, for an hour or more, a slight tendency to emesis was observable. But the frantic, tremulous anxiety had given place to confidence and composure.

"The after-treatment, in this case, was very simple; consisting of mucilage and minute doses of morphine, arrowroot, milk-porridge, and beef-tea. The mouth and throat soreness was treated with astringent washes, and gargle of flax-seed tea acidulated with lemon juice. The recovery was speedy and complete."

There is no superiority in gold *leaf* and iron *bi-hydrogen* over gold *dust*, or pure gold *bronze*, and simple fresh iron *filings*; for, although the former succeeded, we believe the latter would succeed as well, or even better. In the hurry of such a moment, gold leaf, or dentists' gold foil, No. 4, or lighter, can almost always be obtained. But if the conveniences are at hand, we would prefer to rub up gold foil with fresh iron filings in a mortar, and administer the coarse powder, thus prepared, in a little water; for the heavy particles would more quickly find their way to the same portion of the mucous coats of the stomach where the heavy poison fell, while enough of the finer particles would be distributed in the stomach to accomplish the total destruction and neutralization of all the mercurial chloride therein contained.

*Action of Narcotic Poisons. — Electricity as a Remedy.*

*Narcotics and sedatives*, as poisons, that is, in large doses, act primarily on the nervous system, and through that on the circulation; producing stupor, stertorous breathing, depression of the heart, lividity of the face, and perhaps convulsions and delirium. Opium produces stupor, somnolence with contracted pupils, and coma. This order of sequence is the best aid to diagnosis. The narcotico-acrids also possess irritating qualities, producing burning sensations in the throat and fauces; if these symptoms be followed by nervous symptoms, the diagnosis is pretty clear. The equal contraction of both pupils points to poisoning; unequal contraction, or dilatation, to apoplexy; if from liquor, the odor of the breath will detect it.

There is evidently a *law of action*, definitely manifested by different poisons on the nervous system, whether generated in the body, or introduced into the body. The action of nicotine (the quintessence of tobacco) has lately been investigated by M. Claude Bernard, and he finds that mammalia, birds, and reptiles are all destroyed alike by nicotine under similar symptoms, and that whether taken by the stomach, or applied to a wound in the skin, or introduced into the eye. *The arterial capillary system was especially primarily affected through the medium of the sympathetic nerve.* Thus the circulation is arrested first in the capillaries, while the heart continues to pulsate. The veins are full, but they no longer convey the blood onward. It is therefore manifest that nicotine (tobacco) affects the nervous system *of organic* life, just as strychnia affects the nervous system of *animal life*. Convulsions may and do occur in either case, (though not necessarily so,) as among the most prominent symptoms. This is worthy of note, for it must go to show the influence of the sympathetic nerves on the vascular capillary vessels. Dr. Bernard states that he found the *modus operandi* of this poison, when partially decomposed, (?) to be then quite different from that of pure nicotina; for the functions of the heart and lungs were *directly* affected by the latter;

i. e., by the impure article; while the pure poison chiefly spent its physiological action on the *capillary* circulation alone. Besides, the pure article produced tetanic rigidity of the limbs, while the impure, though more largely given, did not. Nicotine (i. e. tobacco juice) may therefore be employed as a remedy for poison by strychnine; but it must be promptly and freely given, as the one poison neutralizes the other. I look upon the continuous current of galvanism applied to the spine, and nicotine as such, or as tobacco smoke or tea, administered by enemata, or otherwise, and ice, *as the only three direct anti-spasmodics known to the medical art.*

Again, it is found that opium and belladonna are mutually remedial; i. e., when either of them has entered the system in too large or poisonous dose. This has been suggested by Dr. Corrigan, and proved by Dr. Graves. It is shown that if these two articles are given together, sleep is not induced; but if given separately, their individual and peculiar effects are realized.

For urine poison, Dr. Jones says, "I will rapidly run over the general mode of proceeding in an ordinary examination of the urine. The urine cannot be well seen unless in a transparent vessel. A six-ounce vial, filled with the urine, and sediment, if there be any, will be sufficient for every purpose. If possible, the urine should be put into the bottle as soon as it is passed. The first test to be used is litmus paper. The question you ask is, What is the state as regards *acidity*, not as to the quality only, but as to the quantity? Is it too much or too little acid? Litmus paper cannot fully answer this question. It *can* tell whether the urine is ammoniacal, or alkaline from fixed alkali, or contains little or much acid, but it *cannot* tell whether the acidity is more than it should be. Simple inspection of the urine is able to solve this question, and that better than any other mode whatever. There cannot be an excess of free acid in the urine without the uric acid being set free, though this often requires many hours to crystallize out. If, then, you wish to know if the urine is too acid, you must leave the vial at rest for twenty-four, and sometimes ninety-six hours, and if there be too much acid, *red crystals* of uric acid *will be*

very distinctly *seen* adhering to its sides, or deposited. The microscope may tell you quicker, but it will not tell you more surely, than the naked eye. Whatever the degree of reddening of the litmus, or the amount of urate-of-ammonia sediment, you cannot with truth speak positively of excess of acid being present, unless you *see* uric acid crystals; and it is only when *free* acid is present in the urine that alkaline remedies are absolutely necessary."

In taking a sample of urine for test, I would here add, it had better be of that made early in the morning, and it should be passed altogether as usual in the ordinary cabinet (chamber) vessel, and then stirred, so as to mix the whole, just before pouring it into the clean vial; and this should be done immediately after its passage by the patient.

The following case of *laudanum poisoning*, treated with electricity by Dr. Russel, house physician of King's College Hospital, shows the value of this agent as an excitor of the great nervous centres: Mary Ann H., aged two months, had taken, through a mistake, some twelve drops of laudanum. The medicine had produced deep sleep, and in the space of two hours, convulsive movements of the extremities. When admitted, the infant was quite insensible and as motionless. The surface was cold and exsanguine; the impulse of the heart could not be made out. Breathing was very difficult, and was performed with intervals of half a minute, at least, between the inspirations. The pupils were very small, and she had lost the power of swallowing. The usual remedies had been employed without success, and in a quarter of an hour more, the child appeared to be quite dead; but while being removed, she was heard to rattle in her throat, and to breathe once more very deeply. This encouraged to a new attempt at restoration. The magneto-electric machine was quickly employed, one pole being placed over the upper part of the cervical region of the spine, and the other over the ensiform cartilage of the sternum. The greatest benefit resulted immediately. Rapid action of the diaphragm followed each application of the poles. A few short inspirations having been induced, were followed by a deep breath. At this time, five hours and a half had elapsed since the accidental administration of the laudanum.

The last remedy — the electric current — was persevered in for an hour and a half, shocks being passed through the chest and along the course of the spinal column, whenever the breathing flagged. At first this stimulus appeared to influence the diaphragm alone; but in a short time the arms were extended; and soon afterwards the legs also, whenever the poles of the magneto-electric machine were applied to the surface of the body. The child soon opened her eyes, and seemed to notice surrounding objects; she then uttered some cries, and the surface became warm. The head no longer sank on the shoulders, but was self-sustained. In about eight hours and a half after the laudanum had been taken, respiration became reëstablished, though not yet with regularity; but the further use of electricity was not required.

Chloroform has been of late much employed* for procuring sleep in those cases where opium is contra-indicated, or fails to act. It is administered in doses of ten to thirty drops, suspended in a little gum-water, or some other mucilaginous fluid, and given at night. It generally succeeds in such cases in procuring for the patient two or three hours of tranquil sleep. In this way it has been much used in cases of old bronchitis, attended with profuse secretion, also in *hemicrania*, and in other painful nervous affections, where opiates have lost all power of alleviating the patient's misery. In any such case, if the chloroform should act too powerfully, electricity is the remedy.

There is a case of poisoning by laudanum related, which occurred in the Middlesex Hospital, and which was ultimately treated, as a *dernier* resort, by electricity. After the stomach pump, flagellation, and a multitude of other inhuman and yet ineffectual means, he was aroused finally by means of electro-magnetism and static electricity. "The pulse soon became more steady, firm, and frequent; the respiration more indicative of resuscitation. The powerful 'electrical machine' was also got into full play before a large fire, and the jar was filled and discharged, when some brilliant sparks and strong shocks were occasionally also passed *through his head*, spine, thorax, and

* British Medical Journal, April, 1858, p. 328.

abdomen. The result of this was, that the man soon opened his eyes, and his mouth, too, for he abused the operators for a pack of rascals who were 'trying specimens' on him. But incomparably the most satisfactory effect was produced by giving him a shock (from the Leyden jar) *on the tip of his nose*. To use a phrase of the ring, he *rallied* wonderfully under this" — a hint worth taking and retaining, for the nose is exquisitely susceptible to all electrical influence. It is probably the most vulnerable point in the whole human body, in all forms of suspended animation, for applying *strong* induction currents.

A very interesting case is related by Dr. M. Barry, of an infant aged nine months, which had been poisoned by thirty drops of laudanum, and was not seen till seven hours afterwards, when in a state of profound *coma*. From this state it was aroused by the employment of electro-magnetism. At first, when the current ceased for a moment, the child sank into a profound sleep, and there was no marked amendment until the means had been continued for three hours; four hours and three quarters passed before it was thought proper to discontinue its use. The child, however, then recovered without any further head symptoms.

Dr. T. P. James gives a case of resuscitation by the primary current of electricity, after poisoning from an ounce of *tr. opii.*, which is thus related in the Lancet of June 19th: —

When the sponge electrodes were applied for a few minutes, no sensible effect was produced; but soon afterwards the muscles of the neck began to quiver, when sensibility appeared gradually to return, and after twenty or thirty minutes the stimulus produced undoubted discomfort, as evinced by shrugging of the shoulders, and attempts to avoid contact with the sponge electrodes; but the first marked influence of its effect was the ejection of a large quantity of fluid from the stomach. In another hour she appeared quite lively; answered questions distinctly, and in a moderately loud tone, though in a somewhat peevish manner. The galvanism was occasionally intermitted for a few moments, when she relapsed almost instantaneously, and "dropped off" in the midst of a sentence which she had commenced during the application of the stimulus.

The pupils remained unaffected till about two hours had elapsed, when they became somewhat more dilated, and sensible to a strong light. All the symptoms gradually diminished, but it was absolutely necessary to reapply it, at longer intervals, until half past five P. M., when she seemed so far recovered as to allow of her removal to the ward. From the easy diffusibility and quick propagation of the galvanic fluid over the whole system, irritation, capable of exciting action almost *ad libitum*, can be applied to any part, or even the whole of the body at one time, and that of a nature void of all the unpleasant results which necessarily follow bastinadoing, cold affusions, searing, the *dolichos pruriens*, and a whole catalogue of equally brutal resources, which, for the safety of the patient, have necessarily been had recourse to, before galvanism was resorted to. By dipping the wet sponges of the electrodes into moistened salt, it assisted the passage of the current and increased the conducting power of the electrodes, or rather *overcame the resistance of the skin*, to a striking degree. In ordinary cases, where the primary current of galvanism is used, the application, if strong, reddens the skin, and may even produce some tumefaction, which remains often for hours. But in this instance, although the current was probably three or four times as strong as is generally used, not the slightest discoloration was observable. It should be noticed that as soon as she was allowed to fall off into a deep sleep, (which she was occasionally permitted to do, after the extraordinary influence of the battery was fully proved, so as to be relied upon, in rousing her instantly from the deepest narcotism to a fretful impatience,) then the pulse gradually lowered in its power, became slower in its action, and irregular in its movements; but no sooner was this remarkable stimulus laid on again, from time to time, than the pulse rallied — was regular, fuller, and quicker; and the respiration, that was previously labored, slow, and unequal, now became more frequent and deeper. The countenance also evidenced, in a striking manner, the singular influence of this agent. When she was admitted, the cheeks were of a leaden hue, and the lips of a tawny color; but after the expiration of one hour, with the use of the galvanic

compound battery, they resumed a somewhat natural tint. The patient completely recovered.

Dr. W. Braithewaite, of the Leeds school of medicine, the author and editor of "Braithewaite's Retrospect," says, "Recent observations show the wonderful efficacy of electricity in some cases of poisoning, and will confirm the remarks made in former numbers on the efficacy of electricity in arousing the patient from his stupor, when under the influence of opium. An electro-magnetic apparatus ought now to be in the possession of every practitioner of medicine.

"In the extreme case of opium poisoning referred to, where all ordinary means had failed, cerebral congestion was urged as then offering an objection to its use, but admitted not to be sufficient, in such a desperate case, to set aside the trial of it. It was immediately put in use, and with the happiest result. With an assistant rapidly rotating the wheel, the ball electrodes were applied at first to each side of the neck, and then moved along down behind the clavicles. The arms and body were at once moved convulsively by it, but the patient lay as unconscious as before. One electrode was then passed *over* the region of the heart, and the other to a corresponding point on the right side. In an instant, his eyes opened widely, and with a ghastly expression of countenance, his head and body were thrown one side convulsively, and he groaned. He now sank back into his reclining posture, and was again instantly asleep. The balls were reapplied in the same manner and situation, with similar results, for several times. Reaction was soon positively established; the heart had received a sufficiently strong impulse; the pulse was becoming rapidly developed, and the whole surface warmer. They desisted, and watched him attentively, allowing him to remain quiet for an hour. Reaction continued satisfactory, and when the hour had expired, he could be awakened by shaking him and calling his name loudly. There was no further occasion for the battery." (But this must have been no battery, but rather a magneto-electric machine, which indeed answers the very best of purposes in such a case.) The writer says further, —

"Before closing this subject, I would add, that electro-mag-

netism will be found highly useful in some forms of disease, particularly those of a *congestive character, where oppression of the organs, and of the nervous system particularly, prevents reaction, and thus speedily destroys life.* In practice, I think we frequently see cases where death seems to occur by an *obstruction*, (or *cessation of action*) of the functions, or of those imperative organic movements which support life, more than by any absolute exhaustion of the organic functions, or of life itself. In such cases, the Faradaic currents of electro-magnetism, or magneto-electricity, might communicate an *impulse* which would renew those sympathetic actions between the organs (if no positive lesion) upon which the *continuance* of life depends."

In all cases of *asphyxia*, electro-magnetism must be useful; and I believe it can be applied in many instances to stillborn children with the happiest effects. The author has used it thus, and would add that only a low degree of current should be so employed.

*Suspended Animation.* — In what class of cases are we to resort to electricity as a principle, or as valuable aid, in restoring the breathless? *In all recent cases*, I answer, (and in some later,) where life has been arrested by the suspension of that process of combination between the blood and oxygen, on which the calorification and animation of the person depend. This must be aided by smart and persevering *slapping* and *deep-shampooing*.

Life is a *power*, located or centred in the organic nervous system, and is capable of preserving the body from decomposition as long as it (life) continues in the organic ganglionic nervous centres, no matter *how long* that time is; but it requires a certain amount of oxygen in order to make itself manifest; or rather to make manifest the operations which characterize life, viz., respiration, circulation, and animal heat. Life may thus lie dormant for days. Persons apparently lifeless, as in *trance*, and other suspended animation, have, after a long time, again resumed the functions of life. Some animals, as frogs and eels, may be frozen solid, and yet recover.

More definitely, therefore, I may answer: if it is a case where

any serious mechanical injury has been inflicted so as to produce a grave or mortal solution of continuity, or where the blood has been poisoned so as to be disorganized, or where an important organ has been subjected to previous morbid change, or where the *vital powers are exhausted*, as by protracted suffering, labor, and pain, — in any such the chances of doing harm would be greater than the prospect of doing good. On the other hand, we might instance, as proper cases for the electric effort, all such as occur from drowning, chloroform, opium poisoning, tobacco poison, rum poison; hydrogen charcoal or carbonic acid gas suffocation; sun-stroke, or lightning-stroke; *stun*, as from a fall, blow, and *shock*, mental or physical, if it occurs without structural injury; or when the chemistry of respiration is suddenly arrested, as in protracted fainting; or in true *suspended animation*, as the sequel of illness or sickness, and there is a question whether it be real death.

But it has been recently questioned whether, *in any such case*, electricity in any manner can be of service. Dr. B. W. Richards, of England, from experiments on dead animals, contends that it not only fails to do good, but actually does harm. He does not tell us what kind or power of battery current he employed, nor *how* he used it; but says, "The results from *galvanism* are negative in kind, but unhappily they are more than that. If, in an animal just dead, galvanism be applied, muscle after muscle may be paralyzed separately; all the muscles in one part of the body may be bereft of their irritability, while the other muscles, which have not been galvanized, retain theirs." Yes, this can be done; but where we hope for life it ought not to be done. Moreover, the same result may be obtained from simple slapping, friction, or deep-shampooing of the same conditioned muscles. A strong man can take the hand or arm of a vigorous and healthy babe, or of a delicate lady, and rub it so strongly for a minute or so, that it will become completely paralyzed for a time. Why? Because the rubbing was out of due proportion for the flesh of a delicate person. It was abusive treatment. So if the quantity, or intensity, or both, of an active battery is allowed to run steadily up or down a limb or a single muscle, or the whole body, it

may over-excite; especially so if concentrated through pointed metallic electrodes, and directed to a single enfeebled muscle; and if there is little or no fountain of vitality left to respond to it, or to draw upon, such a procedure must prove as unsuccessful as trying to kindle a fire from a mere spark by abruptly throwing on large sticks of wood. Precisely thus we may help to kill or cure, in these cases, according to the method and skill of the operator. Tell me the case, when, where, and how the given current is applied, together with the collateral aids, and I will venture a prognosis.

*For restoring the apparently dead*, the following are the most natural and simple means to this end, and are approved by the most experienced: —

*Rule* 1. If from intense *cold*, rub the limbs, the face, and especially any frozen part, and sometimes the thorax, with snow, crushed ice, or cold water, say for five minutes; then rub still more lively with naked hands, and continue it until reaction is well set in. As a general rule, restore warmth *only by slow degrees*. It is better for these cases to perform the handling and flexing of their limbs, and squeeze and mellow their deeper muscles, *while in a cold place*, than to bring them suddenly in by the fire; indeed, this latter plan always increases suffering, and is very dangerous.

*Rule* 2. If from intense *heat*, or *sun-stroke*, or from *apoplexy*, *cold* should be applied to all the upper spine, from the base of the skull to the dorsal region between the shoulder-blades; and in some cases extending it up over the head and well down the spine. The head and shoulders should be kept well raised and quiet. Tight clothing about the neck should be quickly loosened. Ice broken fine, as by pounding it in a coarse cloth, is the most effectual; it can be borne from five to twenty-five minutes; then interpose a fold or two of a napkin; and after a quarter or half hour place more of the folds of cloth between the ice and the skin, and so let there be some hours or days before entirely removing it. The thin India-rubber ice-bag is the neatest and best for this purpose.

*Rule* 3. If from *drowning*, or from any other suffocation, or from narcotic poisoning, get an electric apparatus, a stomach-

pump, blankets, and dry, warm clothing. But instantly proceed to handle the patient by rolling, rubbing, slapping, and mellowing; and provide for as much fresh air to the face as possible; for what is to be done for these cases is to be done by a method and a will, and it must be done quickly. Call to your aid any and every person who can lend a hand, with dexterity *and in unison.* Aim to restore *breathing* the first thing. If water is supposed to be in the throat and lungs, roll him over and over, with his head low and his mouth wide open, and the tongue well and surely pressed, or seized and fully drawn out of the mouth. At the same time, and all the time, do and keep doing all these things.

*Rule* 4. While all other things are thus being done as well as possible, grasp the arms of the patient just above the elbows, and draw them steadily and regularly upwards until they meet above the head, and so retain them in that position for three or four seconds; this is for inspiration, or drawing the air into the lungs. Then, in unison, let the arms down steadily and quickly to the sides, and there retain them for a second or two only; this is to force the air out of the lungs; and if pressure is made at the same time on the breast-bone, short, hard, and quick, it will aid it. *Repeat these processes alternately, promptly, deliberately, fully, and perseveringly, for at least two full hours after all pulsations and breathing have ceased;* or until some decided spontaneous effort to breathe is perceived.

*Rule* 5. So soon as spontaneous breathing is fairly observed, *instantly* cease these proceedings, and as instantly resort to hot bricks, or bottles of hot water, to be applied to stomach, back, feet, hands, and limbs; so by every effort now try to restore warmth and circulation. But if the breathing falters or fails, resort again to the "*ready method,*" by lifting and lowering the arms, as just described, and which has been so kindly urged by Dr. H. R. Sylvester. Exchanges of dry, hot cloths or blankets should be renewed to the body and limbs, and with hot cloths strongly handle the flesh of the limbs. See also methods for *mellowing*, and for *deep-shampooing*. *Slapping the skin smartly, and for a long time*, over the arms, legs, body, face, and back, with the hand, or a stout firm leather strap, or a ruler, can be

well alternated with other efforts, which will facilitate circulation through a reflex action. In all such cases, excepting those from cold or heat, this procedure is too valuable ever to be neglected. Indeed, I have seen all these processes going on at the same time; relaxing some one only to give more energy and efficiency to another process just then most needed.

*Rule* 6. Electricity should be applied by times, during all this time, if possible, until respiration and reaction are quite reëstablished. The stronger the faradaic apparatus, the better in such cases as drowning, or laudanum, poison, &c., which is to be got ready and brought to bear on the thorax muscles and diaphragm, and the rectus abdominis, as soon, as strong, and as regularly, i. e., alternately from quarter minute to quarter minute between, as possible. Let one electrode be applied to the back of the neck, and with the negative wipe over the pectoral and serratus muscles and abdominal muscles, and so on about the waist and dorsal spine; thus awakening the nerves and muscles for respiration, and arousing all the vital organs by reflex action.

Next, perhaps it will be best to place one electrode on the right breast nipple and the other on the left, and then every quarter minute reverse the current by the pole-changer; next, move these electrodes over the respective sides of the thorax for a minute or so. Resting only a few seconds, repeat it by placing one pole at the pit of the stomach, and then at the back of the neck, while you begin to wipe over the face with the negative pole. If a small electrode is not at hand, insert *into* the nose a silver pencil, or any small metal, such as the wire tip of the conductor, and so stimulate the Schneiderian membrane from time to time; for this, I find, is a most *rallying* method. If electricity is not at hand, use strong ammonia to the nose to excite the inside of the nasal passage. In all these manipulations let them be simultaneous; and first imitate, and then coöperate with the respiratory efforts of the thorax. Let system, order, and despatch move every head, heart, and hand, and they will be rewarded with very frequent success.

*Rule* 7. If there is *narcotic* poison in the stomach, give mus-

tard and ipecac in large doses, or in any quantity until emesis, or a stomach-pump can be had and got ready, when the contents of the stomach can be pumped out and water pumped in, and so wash it out. Then with the same, throw in strong pure coffee, and such other antidote as may be called for in the particular case. Touch the face, fauces, inside of nose, neck, and chest with electricity, and alternate this with brisk smart *slapping*, and mellowing, and deep-shampooing.

*Very smart slapping* of the face, back, arms, and thorax with the naked hand, or with a large strap or ruler, is the best aid to alternate with the electric applications. Each might be pursued for five minutes, alternately, thus one or the other all the time, but not to the neglect of other means. The feet and hands may also be rubbed, but this is not so important as slapping. Later, and *during the reaction*, after other active efforts are relaxed, large and moderately strong mustard plasters, — say one part mustard to three of flour, — applied to the spine and thorax, will aid to establish reaction, and relieve the peculiar distress. At the same time keep the patient in warm, dry clothing, and rub the limbs upwards, over, through, or under the warm clothing, so as to keep the air from them, which would cool them. *Keep the skin warm.*

*Artificial respiration*, as for persons recently drowned, or in other cases of *asphyxia*, may be most thoroughly produced or aided by calling the thorax muscles and the diaphragm into electro-muscular contractions. This is in one way produced by a strong electric impression on the phrenic nerve in the neck, where it passes the anterior scalenus muscle; but this point is covered by the long sterno-mastoid, and the platysma-myoid muscles. To avoid these, and to find a site for a metal or buck-skin-covered ball electrode, depress the skin and fascia from without inwards, with two fingers placed along the outer border of the clavicular fasciculus of the sterno-mastoid; then, by separating the fingers, and at the same time maintaining the pressure, access may be obtained to the anterior surface of the scalenus, where the nerve crosses it, without any intervening muscles. Here the electrode is to be planted and maintained for some time. The second electrode is to be as quickly applied, on a

similar site of the opposite side of the neck; and the intense faradaic current may be applied, for two or three seconds at a time, with intermissions equally long. The instant the circuit of the current is in contact, the ribs expand, the thorax and the abdominal walls rise, and air rushes with a sound into the lungs.

To complete the inspiration, the arms and shoulders may be pulled up; and to complete the expiration, the arms are quickly put down by the sides, and quick, smart pressure is made upon the chest and abdomen. These operations need to work together simultaneously and rhythmically. Thus actual respiration may be kept up for hours, aided by the electric current only just enough to succeed; relying upon it, because it can succeed, but doing without it a part of the time, if possible, to maintain the actual ingress and egress of air by the ready method.

At death the blood in the capillaries and veins always coagulates, excepting under certain rare conditions. It has therefore been suggested, where a person is apparently dead, or where friends still apprehend that the body is not actually dead, or where there is the least possible chance that life may not be wholly extinct, and efforts are about being given up for resuscitation, to try cutting the flesh, or opening a vein or artery to see if the blood will flow. If there is bleeding from superficial scarification, or if blood flows from a blood-vessel, there is at least a question of possible chance for life; but if no blood flows, life is certainly extinct.

A still more sure test, if possible, is the application of a piece of very *hot iron* to the skin of some portion of the body, and held there for a half minute or so; if the skin is blistered by it, or if it causes redness about the spot of the burn, then there is life, and efforts should be still further persisted in for restoring animation. But if there is only a dry searing of the skin, without redness or effusion, the vital principle or physiology of animal life is truly departed.

Such are the suggestions of high and humane authority. But it must be rare that occasion calls for these proceedings. Moreover, wherever death occurs doubtfully or suddenly, means for resuscitation should be perseveringly pursued and exhausted before these measures are resorted to.

At the suggestion of Dr. J. B. S. Jackson, I insert the following case (which I treated in 1861) to show what can be done in this humane science and art, when earnestly carried out: —

*Remarkable Case of Recovery from Drowning by the Aid of Electricity and Electro-Puncture.**

Early one stormy, ice-making morning in March, I was requested to go in haste to see a man who was just being taken out of the water in our harbor, at the end of one of the wharves. He was supposed to be quite dead already, in all probability, as he had been in the water some time before he could be found, (the time, I suppose, is always over-estimated in such cases by the excited spectators,) and when found, the messenger said, the body and limbs were "cold, stiff, and corpsy," and the eyes and lips very much swollen. He was an athletic seaman, and, as we subsequently learned, was the second officer of the clipper ship Black Eagle, an Englishman by birth, of dark complexion, thick set, and weighing about one hundred and seventy pounds; had been well, was of good health and habits, and had accidentally fallen into the water by slipping upon the icy dock-log. We were by this time on the spot, and found the case much as represented — a cold, rigid, and apparently lifeless body; bystanders exclaiming, as we approached, "It is no use; he is stone dead; it is useless, and nonsense. O, he is utterly drowned; dead as death," &c.

Instantly we inquired for the nearest room that could be had for shelter from the wind and storm, and where we might commence operations for his resuscitation. The back room of a flour store near by was pointed out, and promptly offered for our use, into which the body was quickly carried, face downwards, by ample hands, who at my orders, though faithless and remonstrating, expeditiously removed his wet, heavy, and partially frozen clothing, washed away the mud from his hair, face, eyes, and ears, while others commenced a lively rubbing on the limbs and body with warm, dry towels and other cloths. Some old sacks and a buffalo robe were hastily spread upon a tier of packing-boxes, and upon these the body was raised, to be convenient for protracted labors in rolling, that is, tilting the body from side to side, now this side up and then that; also for other manipulations to be instituted. I should have mentioned, also, that it was stated by those who had witnessed the accident, and those who were near by at the time, that the man was not seen to rise after he fell into the water until some twenty or thirty minutes afterwards — some verily believing it was an *hour;* at least, not until grappling-irons had been sent for and used, and some two or three sailors had jumped in and dived repeatedly in vain for him. One of these finally seized him by the boot, or leg of his pantaloons, and, after most desperate efforts, succeeded in bringing him to the top of the water. This sailor told me afterwards, that he found him sticking in the mud, head downwards, the water being about fifteen feet deep, and that

* Reported in the Boston Medical Journal, Vol. LXV. No. 5.

he himself came near being fastened in the plastic bottom during his efforts to "start him;" also that he found one arm out of his coat sleeve, as if he had tried to remove it while there drowning at the bottom of the sea. This was corroborated by the appearance of so much mud and sand about his head and shoulders, and by the extreme tumefaction of his eyes and mouth.

All was alacrity now, and every one seemed to work with a will, though evidently against hope; some with warm, yes, *hot* cloths, others with their strong, rough hands squeezing and kneading the muscles every where; others' mission was to promote artificial respiration by rolling the body regularly every fifteen seconds, well over on the right side and then on the left, at the same time lifting the arms and pressing the sides of the thorax, and then again suspending this latter, reversing the position of the body, and now compressing the abdomen, thorax, and heart. Thus relays, of some half a dozen each, were organized, and worked on systematically, like good fellows.

I had already noticed that the stomach region was very much distended, and apparently with fluid, notwithstanding so much had dribbled away by mouth and nostrils while carrying him to the store room. A stomach-tube was introduced, (which for such occasions I always take, together with a stomach-pump and magneto-electric machine,) and, by aid of the pump, discharged an incredible amount of water.

Next, we commenced in earnest the application of electricity as auxiliary, or rather as, in my mind, the principal hope in this extreme emergency. The machine was put at work at greatest power. The metallic electrodes, covered for the time with bits of wet rag, were applied, the positive to the back of the neck, while the other was at first glided along over the shoulder to the side of the neck, over the pectoral, serratus, and other chest muscles, first on the left side and then on the right, changing back and forth, say every minute; changing the direction of the current occasionally; also changing the site of the electrodes, bringing the upper, or positive one, to the side of the neck, and over the pneumogastric nerve, then to the brachial plexus, then over the trapezius and cervical spine, back and forth, at the same time sweeping the negative along the lower third of the pectorals, and about the whole waist. The current was thus used most powerfully one minute, as *direct*, and the next minute as *inverse*, and this was continued for one hour; but without any apparent result.

While other things were being well done, I now directed the current through the chest, placing the positive pole to the nipple of the right breast, and the negative to the nipple of the left, the body at this moment lying on the right side, inclining well over towards the face. Instantly there was perceived a quick, short inspiration, much like a sigh; but, unfortunately, this could not be reproduced, though sought for with most strenuous efforts by all hands for some time longer. I now loosened the binding screw of one of the conductors from the machine, and thus holding its metallic tip, (the positive electrode being placed at the *nuche*, while the negative was adjusted with a small sponge-

tipped ivory electrode, the sponge being moistened, and placed in the left nasal fossa,) I made and broke contact in this manner with my hand, every ten or fifteen seconds, retaining the action of the current longer than the cessation. This was a renewed success. Its rallying power was wonderful. Repeated sighing-like inspirations were thus pretty regularly, but seldom, produced, as was evident to me; and at the same time the skin became softer and warmer. It is note-worthy that these sighs, or inspirations, were so slight, and amid such brisk work, and were also so unexpected, that they were discredited by some of the more doubting eye-witnesses. These lively processes were pursued, however, for some half hour longer, during which time the electrodes were placed respectively on the breasts, and sometimes at the nuche and nose, and then opposite the diaphragm, from the lower cervical vertebræ to the pit of the stomach, &c.; but the phenomenon of life appeared to flag a *little*, instead of increasing.

At this juncture I resolved to resort to active faradaic electro-puncture; not primary galvanic, but suitable, or at least admissible, for such a case. Long gold electro-puncture needles, well insulated except at their points, four in number, and four inches in length each, were carefully inserted in quick succession, some two or three inches apart, along the front sides of the chest, two in the lower part of each pectoral, plunging them inwards and downwards between the fifth and sixth ribs, their whole length, thus transfixing the pectoral, intercostal, and diaphragm muscles, embracing the external nerves, and also the solar plexus and the phrenic nerve branches. The introduction of the needles made no visible impression; but the instant the electrodes were removed from the skin, and brought only in contact with the ball heads of the needles, (or the coupling-chain of each two,) so that the electric current actually traversed the diaphragm from the points of one pair of needles on one side to those in the other, there was produced at each contact, i. e., after a delay of some five seconds or so, most manifest respirations, to the infinite delight of all present.

All were now inspired with courage, and this procedure — together with the still faithful labors of the relays for warm frictions, and their rollings for artificial respirations, flexing limbs and squeezing muscles for circulation and warmth — was maintained with encouraging results for another hour or more; for we noticed that if the electrodes were omitted, the respirations, or sighings as they might be called, failed to appear. I now ventured to change again the mode of application. The positive sponge electrode was carried to different points on the cervical spine, then over the sides of the neck to the cervical and brachial ganglia, and then to the opposite side; at the same time, and all the while, the negative (*strongest*) pole was being so moved as to connect with corresponding needles on that side, or alternately applied to the skin; then again to the needles in the diaphragm, then from tongue to needles, and from tongue to anus, alternately; from nose to needles, (the little ivory electrode being adjusted to the schneiderian membrane, and held by an assistant, so as to be readily touched by the attached electrode in use,) also from the various mus-

cles about the chest to the needles, respectively. It now became evident to all, that life was actually *re*-assuming dominion in the body: the sighing was deeper, and more like a natural inspiration; the cadaverous appearance was being replaced by more naturalness of skin, and more warmth, or, at least, less clammy coldness; there were signs of sensation; moreover there were seen tremulous motions in the limbs whenever the nasal electrode, or rectum electrode, was touched; and there was less gurgling sound in the throat.

From this time the current employed was reduced one half; for already there appeared some spasms of the diaphragm and abdominal muscles. A little hot brandy and water was now poured into his mouth, and he swallowed. I touched the electro-puncture needles no more with the current, but left them in their places for several hours. Not for one moment, as yet, were the electrodes allowed to pass into other hands of less experience, as I knew the taper of life would easily flicker out, either by carelessness or by too much or too little help. I therefore took a less fatiguing position, and still holding one electrode in each hand, continued carefully watching and applying them synchronously with the more and more frequent respirations, first at every other, then at every third, then every fifth, and sixth, and so on, according as needed in strength, length, and frequency of application. After a while the electrodes could be spared, at times, from the respiratory department, and were therefore applied with the strongest current, now rather sweeping along over the abdomen, the spine, and limbs, as if bathing him with electricity. The muscles were exercised and stimulated, the capillary circulation increased, and the reflex action became decidedly aroused to the aid of the general machinery and chemistry of life.

In the course of the next half hour the heart-beats became very apparent, and soon the pulse was found at the wrist. The respirations were now partially self-induced, and occurred even when the electrode was occasionally withheld. The man was still deaf, and blind, (the eyes terribly swollen,) and speechless; though he now sighed, hiccoughed, groaned, and struck about with his limbs.

The next six hours' procedure I will not detail, for there was nothing remarkable. At the end of that time (ten hours in all) the man became sensible, could speak, see, and take nourishment. The groanings, and other expressions of pain and unrest ceased, and he then had naps of refreshing sleep. The next day reaction had set in, and he felt sore, tired, and feverish, and was at times a little delirious. He finally recovered, and is a well, hearty, able-bodied man, (excepting his hearing, which is diminished, and he has roarings in his ears when he lies down.)

Thus I have endeavored to describe faithfully and minutely the processes successfully employed in saving the life of this officer. What other power, or how much less process, could have done it? I believe the man's life would have been lost if we had relied only on the "*ready method*" and the ordinary frictions, without the aid of electricity.

# CHAPTER VIII.

## SPASTIC DISEASES. — CRAMPS, SPASMS, CONVULSIONS.

### *Cramps.*

CRAMP is a term we use to define a sudden, involuntary, and highly painful contraction of a muscle or muscles. It may arise from reflex cause, as from *colica pictonum*, and *cholera morbus*, of which it is a common symptom, appearing more frequently in the lower extremities; or it may arise from some irritation in the supplying nerve trunk, or root, (spinal cord;) or it may be the result of over-excitation, or stimulation of muscles, as from cold, or great labor, and then it may appear in any part of the body or limbs.

Cramp is truly a *muscular* affection, arising usually from *undue fatigue*, or even from causes remote in the system, as indigestible matters lodged in the alimentary canal can cause cramps in the legs. Hence the *causes*, in such cases, are to receive our first attention. These may even be cholera morbus, or colica pictonum. These sudden and highly painful contractions of a muscle or bundle of muscles are temporarily relieved by friction, and firm pressure over the spasmed muscle fibres, or by a ligature applied around the limb above the affected muscle. This may and does occur sometimes in the muscular structure of the stomach. There may be a troublesome, nervous cough in one case, or sneezing in another, or yawning, or twitching, or tremulous eye-winking. Now, all these are but varieties of *clonic* spasms — an irregular contraction of certain muscles. Sometimes hickups set in after some severe accident, from the profound jar of the nerve centres, and continue for weeks, and yet the patient may recover under proper treatment.

*Treatment.* — Pressure, handling, and heat are the first and immediate remedies, to be speedily put into effect; then rectify

the exciting cause. If protracted, or prone to repeat, prescribe the warm bath, a dover's powder, and rest; if not caused by irritation in the spine, electrify the muscles and faradaize the skin over them.

*Writer's cramp* is an affection of the flexor muscles of the thumb and fore finger of the right hand and arm. Attempts at writing, often before a signature can be made, produces spasmodic action of the muscles which are thus used, and have been abused. It occurs in certain persons who have strained their muscles in the rapid and protracted use of the pen. It may be known by the almost instant cessation of the spasm when the person ceases to write, and by the ease and facility with which the same fingers perform *other kinds of work* and motions.

It has been ascribed to the use of the steel pen, because it is steel. This is a mistake. There is great difference in pens. A good quill is, no doubt, easier to write with than most steel pens. But a good steel one, as the little Washington medallion pen, fixed in a large-sized pen-holder, will allow the same hand to write fast much easier and longer, without fatigue or spasm, than many other kinds of steel pens. Such has been my own experience. Gold pens do not appear to admit of rapid writing; hence are not so often blamed. But I have no doubt that a stiff, sharp pen, and small holder, are partly the fault. A very similar affection is seen in manufacturers of small articles; and in some seamstresses, who use one set of muscles monotonously, without much rest.

*Treatment.* — The first prescription is a few weeks' *rest.* Electrify the muscles of the affected part daily, and close each sitting by faradaizing the skin to redness. Give *formulæ* 5 and 9, or 10.

*Facial spasms* occur, by times, in paroxysms, with longer or shorter cure, or spontaneous cessations. They may be known by the grimace being confined strictly to the same group of muscles, and usually on one side of the face only. These face spasms sometimes attend chronic tic douloureux, and are doubtless owing to the same cause, viz., some still existing irritative lesion of the nerve trunk, or root. Temporary relief is obtained from seizing the muscles and holding them with firm pressure, or rub-

bing them. Electro-puncture, with long gold needles, and the hypodermic injection of atropine, hold out the greatest promise for cure, where possible.

*Wry Neck.* — When a case of this kind comes under treatment, we are to suspect one or more of three conditions: —

1. *Rheumatic*, as from cold, locally applied; or with a rheumatic diathesis and history. This can be cured by electricity.

2. *Neuralgic*, with organic derangement, and consequent spinal irritation, reflected back from the original irritation.

3. *Spinal disease.* Therefore examine thoroughly on all three of these points; examine the whole length of the spine. Do not be bluffed off by any unwillingness or inconvenience, for it is too important to be neglected. I have seen a case arising from ulceration, where not in the least suspected for a year, which was situated as low as the third lumbar, with consecutive lateral curvature in the dorsal region, and lifting of the shoulder on the opposite side. The wry neck, in this case, arose from the spinal irritation; the shoulder projected only because of the change of body posture. This was not a suitable case for electricity; the patient was referred to Dr. Spring, to have adjusted a spring supporting jacket. Rest to the spine was the cure for the wry neck.

Another case, Miss F., of Charlestown, who is now under my care, was sent to me by my friend Dr. D. H. Storer, with a wry neck. Some years ago she lifted a bundle of cloth that strained her back; it was soon followed with uterine derangement, and this was ultimately reflected back to the spine, producing large double lateral curvature, with intense spinal irritation, and most distressing *torticollis*. The treatment was directed to correct the uterine function; electricity was applied to the shoulder muscles; with a spring supporting jacket, reaching from pelvis to shoulders. This patient is recovering.

*Treatment.* — If neuralgic in character, treat it as a neuralgia; thus by faradaizing the relaxed side. If rheumatic, treat it as a rheumatism, in all respects, internal and external. To this end, electrify all the shoulder and neck muscles through large sponge electrodes; observing an up-running current on the contracted side, and a down-running current on the relaxed side of

the neck. That is, while bathing with electricity the trapezius and other muscles on the weak or relaxed side, observe that the positive is generally nearest the head; on the other side the reverse. If there is an irritable spine, apply ice, in the long rubber ice-bag over folds of cloth, so as to maintain the application for as long time as possible, twice a day, but only at a moderate coldness on the skin. My practice, in applying ice in *chronic affections* of the spine, is, to take an hour regularly after breakfast, and adjust the patient in bed, or chair, with ice-bag along the spine, over night dress; and over more cloth, if the ice is any way painful. For one, two, or three hours, this is to be maintained. Then order that a long and thick folded towel, wrung dry as possible out of cold water, be applied in the place of the ice, and well covered, so that the patient may move about. After tea, early in the evening, the ice is again applied, and at bed-time the cold water dressing follows for the night. By morning the towel compress is dry, and the patient can breakfast before repeating the ice. In this way, it is possible to keep the spinal region cool for weeks or months; and this is one of the principal means by which I have been enabled to cure so many spinal cases, and other affections depending upon spinal inflammation or congestion.

*Asthma and Angina Pectoris.*— Of both there are cases that are purely nervous, and are radically cured by the skilful employment of electric currents. M. Duchenne remarks that it is the *fit* in angina that kills; therefore the work to be done is first to prevent its return, or to break its force when on. His practice, it seems, is to apply, during the fit, a small sized electrode to each of the nipples of the breasts in man or woman, with a full current of electro-magnetism, which of course was painful; but this he finds will break up the agonizing attack, and cause it, together with the other varied phenomena that attend it, to disappear at once. Then, in after days, some cautious Faradaization practised from time to time over the still existing painful spots on the thorax chases away the remaining angina.

It is now believed that asthma usually depends upon a *morbid state of the medulla oblongata* and spinal centres, which manifests itself by throwing the entire group of inspiratory muscles

into spasmodic action. Schrœder van der Kolk has shown that muscles associated in action are supplied by nerves arising from special *groups of mutually associated and connected ganglion corpuscles;* therefore disorder of this group would be manifested in that *entire class* of depending muscles.

It has also been shown, as a physiological law, that the skin, covering parts moved by muscles, is supplied with sensitive nerves, arising from the same segments of the spinal centre as the motor nerves of those muscles arise from. As an almost invariable premonitory symptom of asthma, there is an itching of the skin under the chin, over the sternum, and between the scapulæ. Dr. Salter remarks that this is evidently a subjective sensation, and indicates an irritation existing at the roots of these nerves.

In persons liable to epilepsy, recurring at regular intervals, fits of asthma sometimes take the place of, or serve as substitutes for the epileptic fit. Acute hydrocephalus may present paroxysms of asthma as a symptom. Previous to the occurrence of asthma, the state of the nervous system indicates an affection of the nervous centres; there may be mental excitement, or depression, or slight convulsions, &c. We are inclined to the belief, therefore, that during the paroxysm of asthma the chest is distended to the greatest possible extent, and that all the muscles of inspiration are in spasmodic action, i. e., *tonic spasm.*

The bronchial muscles are probably those of inspiration, and, according to Dr. Kidd, are associated in the spasmodic action of other muscles of inspiration. Breathing is carried on by the voluntary effort to aid the muscles of expiration; and as soon as this is relaxed rhythmically, the muscles of inspiration, like so many *stretched* elastic bands, distend the chest again with inflowing air.

*Dyspnœa*, and many asthmatic-like affections, are usually relieved, and not unfrequently cured, by means of electricity. My method for these cases is to employ the primary current (*galvanism*) of considerable strength, say twenty to forty Daniell's elements; applying the negative sponge electrode on the *umbilicus* stationary and with the positive begin bathing the thorax and sides of the neck, using half current, for two or

three minutes; then allowing this electrode to come to rest at the back of the neck for several minutes. If fainting or dizziness, employ less current; if no sensible effect, increase it, and continue it ten, fifteen, or twenty minutes. Repeat it as often as the case requires, even if that be every hour. If the primary current is not at hand, employ the extra, or secondary current, in the same manner.

*Carpo-pedal Spasms.* — A spasmodic affection of the chest and larynx of infants between the third and ninth months, attended with difficult breathing that is asthmatic. It is characterized by protracted suspension of breathing at intervals, and great difficulty of breathing, especially upon waking, swallowing, or crying; the thumbs are locked, and the feet and hands are rigidly bent for a long time; the paroxysm is often terminated by suffocation, and perhaps convulsions. Treat the case like the foregoing, only using a very much smaller current; bathing the throat more with the negative sponge, and electrifying over the diaphragm, thorax, and abdomen with both the sponge electrodes, by hazing, or double-circle movements. Repeat it in the fore part of every day for several times. Lance the gums, and give rhubarb and magnesia in moderate doses every other day.

*Spasm of the Diaphragm, or Cardiac Apnœa.* — This is a difficult breathing, although there are open and free air passages; not panting breathlessness, but a *suppressed* breathing. The struggle for breath is due to spasmodic contraction of some of the muscles of respiration. When the patient can express himself, the apnœa is spoken of as being around on the outside of the chest, as from seeming external pressure or bandage. This is often attended with darting pains through the chest — cramp. In fact, it is much the same in effect as true *angina pectoris.* There is, during the paroxysm, either irregularity or prolonged absence of the pulse; the heart being so restrained in action as to give too little impulse to the blood to be felt in the arteries. The surface of the body is cold and pale; the face expresses anguish; and if the muscular system in other parts is involved, there are cramps, but not convulsions; and if the spasms permit, the patient is in constant movement, seeking some posture

for relief. The local pain, which is always acute or lancinating, is between two well-defined spots; as from the lower part of the sternum, through the chest, backwards, to the lower part of the dorsal vertebræ. I believe this pain to depend upon a persistent *spasmodic contraction of the diaphragm*. In some cases the limbs will also be affected, as one arm, which, during the seizure, may be in a state of intense suffering, with more or less rigidity.

In all cases of death by cardiac apnœa, (as suddenly by lightning stroke,) the final act is one of persistent muscular contraction. The heart first failing, the muscles of the chest become fixed from tonic spasm; the voluntary muscles follow next; and the whole body, left more or less rigid, may pass into rigor mortis without any intervening relaxation of the muscular system. The remedy here is excessively HOT drinks, *hot with heat*, and with *alkalies*, as ammonia, peppermint and soda, in very hot water; then electricity over the solar plexus.

*Hydrophobia.* — The most characteristic, and indeed the peculiar feature of *rabies*, is a sudden and involuntary inspiration, followed by several shorter ones; the throat muscles are at the same time violently contracted, so that the glottis closes with a persistent spasm for a few seconds, and the attempts of the diaphragm to descend and the muscles of the thorax to elevate the ribs, are frightfully frustrated from moment to moment. This is not continuous, but alternates with relaxation of glottis and muscles, so that successions of sobs or sighs take place, as we usually see in such cases. Sometimes the bite is difficult to cure, is inflamed and irritable; but most commonly it seems to heal kindly, and only inflames at a later period; but it does not appear that either of these conditions is necessary to the issue. We know only the category of symptoms, and we know absolutely nothing more. We have here no test to apply to the disordered functions by which to measure information.

The dangerous symptoms appear, usually, about six weeks after the bite, though the period may be shorter or longer; but when once begun, they go on most rapidly to a fatal termination. At the very first there is a general feeling of *indisposition*, then a convulsive constriction of the throat in attempting to swallow

liquids, and a slight increase of the pulse; then comes an instinctive shudder at the sight of any fluid, followed by a remarkable erethism of the nervous system, which produces, as we have just shown, spasmodic contractions of the muscles, especially about the throat and larynx, and convulsive paroxysms at the least jarring noise or sudden movement. In this stage the patient is especially excited by currents of air on any part of the person, and the spasms may be thus renewed even after death. The unhappy victim of this frightful malady at last usually becomes violently delirious, and rapidly exhausted, and he either expires in a convulsion, or more frequently becomes tranquil before death, and sinks painless and exhausted.

On the records of the Massachusetts General Hospital there are only three cases of hydrophobia: the first, a female, aged seven years, bitten one month before the attack, and lived two days; the second, a male, aged thirty-one, bitten five months before, and lived four days after attack; the third, a boy, aged three and a half years, bitten thirty-seven days previous to attack, and lived six days. Another case occurred this past year in Brookline. A vigorous boy, aged five and a half years, had his face bitten by a large watch-dog, April 6, 1864, and after the wound healed, the boy was as well as usual till thirty days after he was bitten, when he was taken in the night with nervous twitchings, which soon increased to violent spasms, convulsing his whole body; and he died conscious about fifty-four hours after the ushering in of this terrible disease. No kind of treatment was found able to arrest the fatal result.

In many cases of rabies the sufferer keeps up a constant hawking and spitting up of adhesive mucus and saliva, which is often thought to resemble the barking of a dog; it occurs, however, mainly or only during delirium, and perhaps in consequence of *it*, as we often see this symptom in insanity; so also may occur the inclination to bite. The hypodermic injection of atropine (see *formula* 33) *near the site of the dog-bite;* and moistened snuff or tobacco applied over the *solar* plexus, at the pit of the stomach; and pounded ice in a dry bag of rubber applied to upper spine, from occiput down, and long continued, though graduating its action by folds of cloth between it and the back

after its controlling influence is obtained, would be my prescriptions in such a case.

*Tetanilla.* — This is a disease allied to tetanus, and in grave cases it passes into it. It was first described by Dr. Trousseau, of Paris, and consists of contractions of the hands, arms, or lower limbs, one or all being affected, but the upper being usually the first to suffer. The attacks are preceded by formication, anæsthesia, and diminished voluntary power in the limbs; attended with more or less pain extending along the principal nerves, and radiating sometimes into the trunk. In grave cases the whole body finally becomes involved, and there is some pyrexia. In tetanus the muscles of the jaws, neck, and trunk, are first affected; while it is a characteristic of tetanilla, that the spasms *commence in the limbs*, and then extend to the muscles of the trunk and neck. Another specially distinctive feature of this affection is, that the contractions can be brought on at any moment, by compressing the nerve trunks, or the vessels of the part.

This disease is believed to be rheumatic in character, usually, and is caused by enfeebling processes, in persons predisposed to this peculiar nerve irritation. Epsom salts, turpentine and oil, in full doses, or bleeding from the arm, or cupping along the spine, or leeching, are the most successful early means in all cases that are any way robust in constitution. The next most useful remedy is quinine, followed by small doses of aconite, opium, or belladonna; choosing these according to temperament. Primary galvanism from ten to twenty Daniell's elements, in a down-running, steady current, and persisted in for an hour or so at a time, will materially aid in quelling these painful contractions or spasms. Unless speedily relieved, such cases prove rapidly fatal. In one well-marked case, which was giving me much anxiety, I ordered a handful of tobacco leaves to be quickly moistened and applied over the abdomen and stomach, and I believe it was one of the most useful aids in saving this patient.

*Tetanus*, when idiopathic, or continuing even as the sequel of a traumatic origin, provided the thorn, nail, or sliver is removed, or the included nerve is released from the accidental embrace of a ligature, may be sometimes successfully treated by

Faradaic or Galvanic currents, carefully and continuously *directed down the spine*. Dubois-Reymond, however, thinks that the current does not penetrate to the spinal cord, unless the current is great, or is interrupted, or reversed; neither of which is under any circumstances allowable. True, I cannot speak from any satisfactory treatments of my own, as yet; but from what I have observed, I certainly should apply the primary *direct* current of galvanism to such a case, and perhaps a very gentle, even, and long-continued current of electro-magnetism, down the spine, and from the coccyx down to the foot, if the first cause had *not* been there situated.

*Idiopathic Tetanus.* — This is best treated by ice to the upper spine, and then longer continued over folds of dry cloth for days and nights together; this, with ether inhalations, will lull the spasms and wilt down the tonic contractions; but these alone do not cure the disease. Opium with ipecac or antimony, is our sheet anchor; to be given in grain doses, early and continuously, every hour at first, and then less and less after, but for many days. Keep the patient quiet, and in a warm, dry, and even atmosphere, and give nourishing but easily digestible food, with coffee, tea, or broth, but no sort of stimulants.

*Traumatic Tetanus.* A case of which I once had to treat occurred as the result of a ragged wound made three weeks before, by a circular saw, in a bucket factory, in the town of Marshfield. The wound had healed, apparently, before the lock-jaw came on. It was a very violent case, in a formerly sea-faring man of large and strong frame, who had been under treatment for a day or more without relief. A sub-cutaneous horizontal section of the cicatrix, with *warmth* and quiet, quinine and morphine, in large doses, constituted the main treatment, and this man had a gradual and good recovery.

*Tetanus and chorea* are two very distinct nervous affections, both marked by striking objective phenomena, and consisting of acts of the muscular system, which are not only involuntary, but are uncontrollable; and these must be exactly distinguished the one from the other. The spasm of tetanus is sudden and violent, and alternating with relaxation; the system soon shows

febrile symptoms of a low dynamic type, and there is rapid prostration or sinking. In chorea we see the restless jactitation, the tossing hither and thither in the most uncertain manner of one or more limbs, or of the whole body. In the worst cases of chorea, the patient becomes gradually exhausted from constant restlessness, inability to take food, and insomnia; terminating in delirium, coma, and death. *The one is violent, and in distinct paroxysms;* the other is hap-hazard, and more or less constant while awake.

A case of tetanus, of two months' duration, I lately saw, produced by the falling of a window-sash upon the back of the neck of a young man twenty-four years of age; for whom a great variety of treatment was tried in vain. Finally, the application of crushed ice in the long rubber ice-bag, and the sub-cutaneous injection of the acetate of morphine near the spine, and the free inhalation of ether, were the only means found that could hold the violent spasms any way in check. But these were resorted to perhaps too late. Electricity was not attempted. A *post mortem* showed effused *blood spots* along the coverings of the spinal cord, but mostly about the fourth cervical vertebra.

### *Chorea* — "*St. Vitus's Dance.*"

*Chorea.* — What is its pathology? Is it simply an insanity of the muscles? Very little is written, and probably less is known, of this affection than of most other nervous phenomena. Shall I venture to say, it is a peculiar kind of disturbed balance of nerve forces? But this, though true, does not define it, nor does it help us to its correct treatment; for we might as justly say that ataxie locomotrice, epilepsy, cramps, spasmo-paralysis, or agitans, are unbalanced or disturbed nerve forces. I may safely say, perhaps, *it is essentially a functional disorder of the nervous centres*, produced often by strong mental emotion, especially by fright, or from *fear* of blame or punishment; or else the malady is set up by gastro-enteric irritation, or is attended with heart disease as the results of rheumatism. Heart disease is not by any means always to be found in cases of chorea; but we must be wary on this point. I will venture to say, further,

that *chorea is most usually of a reflex nature*, and in this light we are to study it, and to treat it.

All muscular movements in man are either voluntary or automatic. Those which are automatic are the result of reflex nervous action, involving the necessary agency of a central reservoir of nerve force, a sensational impulse transmitted to that centre, and a motory one emanating from it. Moreover, automatic actions may be either independent of, or associated with, consciousness; but where they are not so accompanied, they probably only involve the agency of the spinal cord, or the ganglia of the sympathetic system. But where they are accompanied by consciousness, or are the result of an idea, or will, the stream of nerve force which produces them must pass through the sensorium, or centre of consciousness, which is, though not necessarily, assumed to be in the cerebral ganglia.

The faculty of the will, which is superior to and distinct from consciousness, is not exercised in the creation of nervous impulses, as is generally supposed; but, according to Dr. Bond, "when the will force is exercised, it is in *directing*, or in accordance with those nervous impulses which are conditioned by foreign or external influences, or by the internal influences of our own mental economy." The *will* can and does regulate and control many movements *which are usually automatic* in their character, and which show themselves as such, when the power of the will is withdrawn, with as much clearness as other movements over which the will can have no influence whatever.

We know that automatic, instinctive, involuntary, or otherwise called "*reflex*" movements, are induced by the influence of a sensational impulse upon a nerve centre, from which a motor impulse is echoed back to the muscles of the part acted upon, and hence the phenomena. Such centres are found in the ganglion cells of the spinal cord, as demonstrated in the reflex movements, which may readily be excited in the lower extremities of a paraplegic man, from inflammation of the spinal cord; or in the brain, as is observed attending ideas proceeding from the gray matter of the cerebrum.

We also know that *the power of the will is exercised in different degrees* over different automatic movements, and even over

the same sort of movements at different times, and under different circumstances, excited as these movements are by various kinds of sensory impulses. In health a greater degree of command is exercised by the will over the ideas, than over the emotions; and these, in their turn, can be more easily controlled than the impulses derived from the special senses; and these still more than those derived from the sympathetic, or the nerves of general sensation.

In chorea the movements are evidently *involuntary;* the patient does not will them, although in mild cases they may be partially restrained or modified by the will. If such a patient is requested to hold still the affected limb, and apparently concentrates his whole mental energies on that subject, he will fail to hold it still; not from want of the will to succeed, but because his power of volition is not sufficient to overcome the impulses to movements received or reflected from the nerve centre.

The fault does not lie in the perversion of the will so much as in the diminution or loss of it. The eccentric movements of choreic patients, Hassie has noticed, are not so much from a want of coördinating power, as the interpolation of involuntary motor impulses at the same time and among the voluntary ones; to which, unless the will be called very strongly into action, they are superior in effect.

The *involuntary* character of the movements of chorea must necessarily be recognized, whatever may be the source of the affection. Hence, even the most violent movements in chorea are prolonged, and yet without much sensation of fatigue. On the contrary, the rule is, the more the *will* is exerted in the production of any set of movements, the sooner does that particular physical sensation occur, indicative of nervous exhaustion, which we call fatigue. The involuntary movements of the heart go on for a lifetime, without rest and without fatigue; while the voluntary movements of the hand and arm, acting under the guiding influence of the voluntary will power, soon fatigue, and must have rest.

*Treatment.*—In cases of distinct evidence of a rheumatic character, or even of suspicion of a rheumatic diathesis, we are to speedily commence the alkaline, as a part of whatever other

treatment we may see fit to adopt, and which may go on in conjunction. If it is a violent case, with great agitation and sleeplessness, we must use opium or morphine, combined with ipecac or antimony, or else with quinine and diffusible stimulants. The dose must be graduated to the case, and repeated at regular intervals for a few days, to calm the nervous system and obtain sleep, for these patients may sink and die from sleeplessness and sheer exhaustion. If there is great prostration, the use of quinine and strychnine in small doses, with brandy, wine, or whiskey, together with nourishing food in moderate quantities, must be conjoined with faradaization, sunlight, and air; cold, quick *sponge baths* twice a day, and regular *rhythmic* gymnastic practice, or passive, systematic muscular movements. Whatever methods will promote natural functions will best promote and increase nutrition; for this, we must bear in mind, is invariably, and in a superlative sense, a disease of nervous debility, with irritability and loss of control.

The treatment for obstinate chorea should, in fact, be threefold — mental, medicinal, and mechanical. We must first, and at all times, plan to withdraw and constantly occupy the patients' mind from the unnatural character of their own movements, so as to enable them to overcome *the habit* of a morbid consciousness. Then, by means of the electric current and other measures, we may break the chain of exalted nervous impulses, which are so unduly reflected from the cerebro-spinal axis, and remove the dominant idea which, at least in some cases, appears to beleaguer the brain and thoughts, and restore the enfeebled power of the will to its healthy control over all voluntary movements. From hereditary tendency or constitution, or some induced predisposition, we find the nervous system in an unduly susceptible state, and evidently connected with imperfect nutrition, or too rapid waste of the great nerve-centres; and sometimes developed by or associated with functional or organic disorders. These are to be searched for, and, if possible, set right. As speedily as can be we must control, at least temporarily, as by ether or anodynes, the violent cases, or there is death from exhaustion.

So that, while we amuse and reassure the mind, and depend mainly on therapeutics, that in the long run is to tone the

nervous system, — such as electricity, quinine, iron, arsenic, silver, and zinc, — we should prescribe light gymnastics, but such only as are systematic, rhythmic, moderate, and simple. This is of great value in long-standing cases. Even the methodic *skipping the rope*, if not too violent, but frequently repeated at stated times, answers the purpose very well, particularly among the poorer classes. Calisthenic exercises, or deliberate regular steps, or military drill, or other exercises, may for some be preferred. Periodic, regular, voluntary movements are to be practised by the most affected muscles, instead of those which have been involuntary and erratic. In a word, the *will*, the nerves, and the muscles are to be educated to overcome bad habits.

*Faradaization* of the dry skin, and electrifying the affected muscles, are my most usual methods for chorea, and the majority of all the cases that present for treatment will receive it. When there is much *hyperæsthesia* and nervous excitement, I defer the application a little, until this feature is reduced, as by frequent cold sponge baths, and internally silver and morphine, or antimony, vermifuge, croton oil, or eleterium with conium, and the horizontal posture, in a dark, still room. We may also prescribe something like *formulæ* 1, or 2, 4, 5, 12, 18, 23, or 24. When this is attained, and in all other cases where a moderate current is borne without fright or suffering, electricity works a very rapid diminution of the twitching movements, and effects a prompt and permanent cure.

It should be applied down the spine steadily for one sitting. Then plant the positive sponge at top of spine, and with the other bathe over the affected muscles. Then finish the seance by using the *wire brush* negative, by painting movements, until the skin is red, over the affected muscles and limbs, and down the spine, for the last few minutes. Repeat it daily, or every other day, or only twice a week, while arsenic or opium with antimony, morphine or strychnine, in small doses, is helping to meet the individual indications. Out of fifty-three cases, thus treated, twelve were cured in ten or twelve days; twenty-two were cured in three weeks, and the balance were cured in from six to ten weeks, excepting two. One of these was a scrofulous girl, who was repeatedly cured, apparently, but relapsed from time to

time; the other, a fleshy girl of fourteen, was the result of injury to back of neck, and complicated with heart disease.

The characteristics of this odd affection are, mainly, irregular and involuntary motions of one or more limbs, and also often of the face and trunk. These twitchings or spasms *do not* continue during sleep. This disease more frequently occurs from fright, before puberty, but not always or necessarily so, and is believed to be connected with enfeebled nerves, and some torpor of the developing system. Its duration may be long as a mere nerve habit, or it may lead on to deformity and idiocy; but it is rarely fatal. Active purgatives once or twice a week, as by *oleum tiglii*, and the persevering use of iron, or of arsenic, as in Fowler's solution, will often cure it. But the primary and direct or down-running current of some ten elements of Daniell's batteries, applied every other day to the spine, with all the precautions and method as laid down for the treatment of neuralgia, will materially aid in arousing and equalizing the nervous energy of the system. Particularly is this true where the chorea occurs in a constitution tainted with rheumatism. But as "St. Vitus's dance" is now and then attended with a heart affected, of which it may be a symptom, it is always well to examine that organ before commencing the use of electro-therapeutics for the cure of this nervous affection.

My own clinical experience enables me to say, moreover, that where the heart *is not* seriously diseased, and very often, where it *is* greatly disturbed in function, I have scarcely ever failed to cure chorea, even when of ten to twenty years' standing, by means of the direct primary currents of galvanism, run from the nucha to the coccyx, in connection with the *cold douche* to the spine, daily, and continued for a length of time.

Dr. Addison, the senior physician to Guy's Hospital, says, "Whenever I see a young subject the victim of chorea, I always suspect that it has its origin in rheumatism. Believe me, rheumatism is a very eccentric disease; I know of none more so. There is no disease of which we know really so little as of rheumatism in its pathological essence and nature. An old physician of great celebrity was asked, 'What is the cure for an acute attack of rheumatism?' His laconic answer was, 'The cure for an

attack of rheumatism is — *six weeks;*' that is, it is not cured. Let us, however, at all hazards, mind the *heart* in these cases.

I am satisfied as to the ravages committed by this rheumatic poison in the endocardium and pericardium, and that to often without any pain to attract attention. This pericarditis is of a marked kind, for it may occur stealthily, with no pain about the heart.

There are other curious associations between the brain and the heart, here to be noticed. "Epilepsy, for instance, affects the heart, as it sometimes shows itself in a violent fit of *tumult* or palpitation of the heart, with unconsciousness — *epilepsy of the heart.* Emotional influences will produce palpitation of the heart; the emotional influences of fright will cause chorea; indeed, this is *the most common* of all causes of this affection. A dog runs after a child; a ghost story is told by a foolish nurse; a house takes fire; the child is exposed to danger, or perhaps is seized by a stranger, or is flogged by the school teacher, or some horrible agitation is set up in the emotional (or central) parts of the brain, and a choreic state is the result. The fact is, the complication or 'connection of chorea with rheumatism and *heart disease*,' is so frequent, that I always look for it.

"While speaking of the heart, let me remind you that in case there is found a lurking *inflammatory* state of the heart, as endocarditis or pericarditis, whatever else be your treatment, let your patient lie for whole weeks upon his lounge or bed, for although we cannot give the heart *perfect* rest, it is all the more necessary to give it as much as we can. Keep the action of the heart quiet; give tinct. veratrum viride, and avoid stimulus, but give valerian tea and morphine at night, to insure rest, and such cases do then, under galvanism, finally recover, even where apparently most hopeless." Such are the views of Dr. Addison.

We can scarcely ever see a case of acute chorea, therefore, without at least carefully examining for a rheumatic history. If there be no fibrile state present, but if the urine is found highly loaded with lithates, though not of itself sufficient, yet it is highly presumptive of the co-existence of rheumatic discrasia, and perhaps of acute pericarditis also. A great number of examples might be delineated here, to show the success of a

weak primary or a very gentle secondary current, directed for five minutes per day *down* the whole spine. Dr. Dupee, of this city, sent a little boy, Charles C., under a dozen years old, to me, for this treatment, whose heart was not only affected, but together with chorea, the saliva drooled from his mouth, his speech was nearly gone, and his right arm was quite paralyzed. I gave him daily sittings for the first month, (Sundays excepted,) then two sittings per week, for the next month, which quite completed the cure. This fine little fellow is now well and at school.

According to M. Becquerel, too, this affection is susceptible of receiving a happy and permanent influence, if we employ the primary current of some ten Daniell's compound battery, gently applied and directed down the whole length of the spine, by placing one electrode at the base of the occiput, while the other is at or under the coccyx; or we may employ negative sparks, drawing them from along the spine. The former, he says, where the chorea is *not* still the consequence of worms, nor yet of some existing organic disease, as of the heart, &c., has a most rapid catalytical in-working, much as in cases of rheumatism, and resulting in most complete success, alike in cases of local, general, and hemiplegic forms.

It ought to be mentioned here, likewise, that where "*stuttering*" occurs in childhood, or if the patient is still in youth, electricity can restore *power* to the muscles and *dominion* to the will, which, together with muscle drill and muscle education to break up the former bad habits of the muscles, will constitute a radical cure. For these cases we can employ the negative sparks of static electricity directed daily to the muscles under the chin and about the throat, or the Faradaic currents run *from* the posterior cervical ganglia *to* the throat and roots of the tongue, at the same time instituting a daily exercise in the practice of counting deliberately, and repeating or reading words of monosyllables with commas between.

*Hysteria — the Fit.* — In certain persons, especially when under the influence of some violent mental emotion, the hysterical "*fit*" may set in, without any evidence whatever of previously deranged health. But more usually the case gives a history of previous manifestly altered spirits, and by a sensation of pressure and

constriction at the pit of the stomach. Soon this sensation ascends to the neck, and is then described by the patient as being "like the rising of a great ball in her chest and throat, which chokes and throttles her so that she struggles for life." The breathing is irregular and heaving. She becomes much agitated, sobs, laughs, or cries, and her muscles contract violently; or perhaps she lies motionless until her seeming inability and insensibility are disturbed by somebody, or something, which she fears, or decidedly disapproves of. But there are other forms of hysterical outbursts, "which sometimes hang out false and contradictory signals, complicating, or else purely aping other diseases," local or general, acute or chronic.

It is sometimes, perhaps, difficult, yet very important, to distinguish between paroxysms of hysteria and those of epilepsy, particularly if the epileptic seizures occur in hysterical patients. In his late and excellent work on diagnosis, Da Costa shows concisely that "there are usually many well-marked points of distinction," which may be seen, as shown by the following parallels, which are quoted from his table: —

| *Epilepsy.* | *Hysteria.* |
|---|---|
| Sudden and complete loss of consciousness. | Gradual, partial, or apparent unconsciousness. |
| Livid face; show of frothy saliva from the mouth, eyelids half open, eyeballs rolling, grinding of the teeth, biting of the tongue, insensibility of the pupils to the light. | Face flushed, or the complexion remains as natural; no froth from the mouth, eyelids closed, eyeballs fixed, neither grinding of the teeth nor biting of the tongue, and *the pupils do react to the light.* |
| Distortion of countenance. | No distortion of countenance. |
| Patient evinces no feeling. | Patient sighs, sobs, or laughs. |
| *Aura epileptica* sometimes. | *Globus hystericus* usually. |
| Convulsions usually more marked on one side than on the other, and more tonic than clonic. | Paroxysm not followed by much sleep; patient, after the attack, is wakeful and depressed in spirits. |
| Oftenest occurs at night. | Rarely occurs in the night. |

Hysteria is almost peculiar to the female sex; but I have witnessed some examples in men that so resembled hysteria in every detail of symptom that I certainly should pronounce it hysteria if it had occurred in females. The *aphrodisiac* power, — sometimes termed the "*sixth sense*," — the faculty of reproductive perception, the conservative force of species and genera, and distinguished from all other faculties and forces, which has its seat and throne in the reproductive organs, is always admitted to be a modifier or a prime element in the cause of hysteria, occurring in either sex. It exists in the reproductive organs and tissues, and is augmented with their development, (and especially with their excitement, physiological or pathological,) is diminished with their diminution, and declines and dies with their extinction.

But why does this element shade or shape the nervous affections of woman more than of man? Because her whole nature and being are constructed more with organs and emotions to impart life, care, and nourishment to her offspring. Man possesses neither the germiferous, the gestative, nor the lactative organs or powers; nor has he any analogy to the great nerve-disturbing, and constantly recurring catamenial office of the female. His nature is more hardy, and adapted to roughness and endurance, and he is taught to practise it. She is more delicate and emotional by her very nature, and in refined society she is taught or led to cultivate this by very force of circumstance. This seems to predispose all women to be susceptible of hysteria, more or less, under causes external and internal, very far more frequently than men, though I believe she is a hundred or a thousand fold more pure in thought and actions than men are generally.

A woman of a highly nervous and sanguine temperament, with a mind ill regulated and *intolerant of control*, from habits of indulgence, — or, on the other hand, where *trepidation* or *jealousy* has grown as a part of her very nature, and perhaps has been cultivated by harsh treatment, or treatment that was habitually construed to be neglective, harsh, or accusative, — is a candidate for hysteria. Either one of these female temperaments may be heightened still more for the hysterical phenomena

by a sedentary life, with much novel reading, luxurious living, too much of the time in warm rooms, and in a warm bed, by the use of wine and confectionery, and still more by the use of nervines and whiskey.

In hysteria there is generally a moral cause, seen or unseen, which sets in motion a machine thus already highly wrought, and prepared for the development. Dr. Meigs, in his graphic style, says, "The hysterical woman, like the highly-electrified thunder cloud, requires but the point to draw the flash. She sits, like Tam O'Shanter's wife, —

> 'Gathering her brows like gathering storm,
> Nursing her wrath to keep it warm,' —

when, suddenly and unexpectedly, some word, sign, or gesture, or the failure of some word, sign, or gesture, gives the occasion; and we may have direct and sarcastic reproaches, tears, sobs, wringing of hands, perhaps cries and tearing of hair or clothing, clonic convulsions, tonic spasms, stolid silence, or stupor, stertor, or rigid opisthotonos; — then smiles like a May morning, and bursts of loud laughter again, floods of tears, and then a gradual return to a state of gentle composure, wherein the tenderest affections of the female heart come to resume, with unusual supremacy, their wonted sway over the soul." This is attended or followed by an excessive secretion of limpid, water-like urine, and then succeeds the profoundest calm of the constitution, and a feeling of the sweetest complacency and amiableness. Such are the symptoms which leap out, as it were, from a profound repose, and no more anticipated by the patient than by others.

*Treatment.* — Where a fit of hysteria is slight, it requires no treatment; but if it is violent, and occurs in a plethoric person, or if there is coma or an approach to it, the patient should be immediately bled, at least locally by leeches and cups, to avoid the risk of sanguineous congestion of head and heart; or this may be simulated in effect by ligating the limbs close to the body, so as to impede the return of blood in the veins for a while; also, by hot things to the feet, aided by dry cupping, and slapping the limbs, as with a broad leather strap, very smartly. *Faradaization*, by placing the negative sponge on the hand or foot, and with the

positive, (a metal tip, or wire brush,) and full current power, is a remedy *par excellence*.

Bathe over the limbs in long wipes up and down. If she is silent and epileptiform, a touch or so about the end of the nose has a wondrous rallying influence. If her jaws are set, so that she cannot or will not take drink or medicine, just apply the metal electrodes over the masseter muscles on each side, and instantly the mouth is at your service. From a preparation of tincture of assafœtida and fluid extract of valerian, in equal parts, give a tea-spoonful, diluted in a small wine-glass of water. Repeat this every fifteen minutes. There is no harm in giving this order to the nurse aloud, and in the hearing of the patient. The worst fits of hysteria I have ever seen are thus speedily broken up by these simple and common-sense means. Then see that the uterine organs are cured of irritative disease and malposition, with some months of freedom from excitements.

But such a constitution is not sound. It needs a regulated, protracted regimen, electricity, and other means to develop nerve power, hardiness, and endurance, and to reinstate the judgment over the emotions.

*Hysterical convulsions*, cramps, and rigidities are proper cases for the electrical treatment, and are usually benefited by it. Sometimes, and that not seldom, the exalted hysterical phenomena are quite *annihilated* by this means, so that these cases may be said to be permanently cured. In these variegated affections, the testimony of Dr. Becquerel, as also of Drs. Meyer, Remak, and others of high authority, goes to show the uniformly good effects of electric currents in all such cases, *when well directed;* and this is as might be expected, because neither the motor nerves, nor the cerebro-spinal axis are in any way injured. But here we must never employ sparks, shocks, nor interrupted or reversed currents. Treat all such cases as if neuralgia, by running the primary or very even and gentle secondary current *down the spine*, or down the abdomen or limb at first; then try to bring both electrodes below or beyond the site of the cramp, with a very carefully managed direct current cautiously applied, long retained, and as carefully removed.

*Spasms — Convulsions.* — The term *spasm* is used when we wish to express the idea of a local extraordinary or painful involuntary muscular contraction, limited to a single muscle or group of muscles; but more especially when it involves the muscles of organic life, as spasm of the throat, or of the stomach, of the heart, or liver, or bowels; while the term *convulsion* is used to designate the more visibly agitated and extensive or universal muscular contractions, such as when the most or all the muscles of the body and limbs are involved, and especially those of volition. Yet the two phenomena often coexist; and being produced by the same cause, and obedient to the same laws, they become merely convenient relative terms, differing only in degree.

*Spasms* are of two kinds — the *clonic* and the *tonic*. Chorea and some hysterical manifestations afford us perfect illustrations of clonic spasms. The most perfect type of tonic spasm is seen in tetanus. In clonic spasms the muscles are agitated by violent and rapidly alternating contractions and relaxations, which are so extensive as to be often termed *convulsions* rather than *spasms;* while in tonic spasms the muscles are retained strongly contracted and rigidly fixed for a time, in spite of every effort to relax them. Cramp is a local muscular spasm, of short duration, involving one or several muscles, occurring in paroxysms, and attended with pain. Rigidity is a more permanent tonic contraction, and is often the result of nervous irritation in the nerve trunks, or in the great centres.

Convulsions are also divided into two classes; the one occurs without loss of consciousness, having continued capability of thought, and unaltered sensibility, as in tetanus, and in poison by strychnia. Convulsions may occur with loss of consciousness, and with impaired or abolished thought and sensibility, as in apoplexy and epilepsy. There has been much controversy on the condition between epilepsy and convulsions; but as regards the character of the seizure itself, there is no appreciable difference. Convulsions are more likely to occur in children, or from injury to the head, from inflammation of the brain, from teething, or in the parturient state; also attending eruptive fevers, or

Bright's disease, or from gastric irritation, and many other conditions, as I shall soon show; while epilepsy may be known from the recurrence of the attack, after intervals of health, in subjects without apparent cause for convulsions, and by the dulness of intellect, and the slow mental and bodily recovery during the interval.

"*Chronic*" *convulsive diseases* form a very definite group, and are, with few exceptions, readily recognized as such. Recently the true nature of this important *class* of diseases is brought to light by the works of Drs. Sieveking, Radcliff, Schroeder van der Kolk, J. R. Reynolds, Brown-Sequard, Kussmaul, and Tenner. In this work, space will not allow us to point wherein they all differ, and wherein they agree; the conditions upon which they depend, and the treatment indicated or contra-indicated. They can here only be called in review, that the physician may be reminded of the differences, and so employ the electric current *only* where calculated to be remedial, directly or indirectly.

*Idiopathic convulsions*, including *epilepsy proper*, i. e., *idiopathic epilepsy; eclampsia puerorum*, i. e., *idiopathic convulsions of children; secondary, or eccentric, or symptomatic convulsions*, i. e., *sympathetic epilepsy, as uterine, gastric*, &c.; *sympathetic convulsions in children.* Diathetic or cachectic convulsions from deranged nutrition; from puberty; in tuberculosis; in scrofulosis. *Toxæmic convulsions*, arising from retained excreta; *urinæmic convulsions*, or *renal epilepsy;* from metamorphosed plasma, as *pneumonic convulsions, rheumatic*, &c.; from poisons introduced from without, as "*syphilitic epilepsy,*" lead, &c.; symptomatic convulsions, from centric disease, as disease of meninges of brain or cord; tubercle, syphilis, traumatic, &c.; from disease of the nerve centres, as tumors, or "softening."

As aids in treatment, we might mention, that in chronic meningitis, so often confounded with epilepsy, setons and issues are valuable in the former, but of no service in the latter. Bromide of potassium is useful in epilepsy occurring in the nervous temperament. The shower-bath does no good; chloroform and ether only postpone the attack; but *cold sponge baths daily* are grateful, and of permanent advantage, if quickly taken.

*Convulsions in Children.* — *Eclampsia*, more commonly termed *fits*, afflict the young of some families, while other families go entirely clear. There doubtless is often an hereditary tendency; and in some there may be some accidental injury at the base of the brain during birth; and in others there may be disease in the head or cord; or there may be a reflex influence from teething, worms, and other gastric irritations. But from my experience, in both country and city practice, the cause of convulsions in children, in a great majority of cases, I believe is owing to improper feeding, either in times, quantity, or quality, or all. And the greatest predisposing cause appears to be a general irritation, or *hyperæmia of the brain* and spinal cord. But they may result from excessive evacuations, as well as from indigestible or too much food. The exciting cause in certain nervous children seems to be often merely a weak or sour stomach.

*Treatment.* — When the pathological condition in these cases is a hyperæsthesia of the nerve centres, as manifested by nervousness and irritability, especially where coupled with anæmia and complete absence of inflammation, as in the large majority of these cases is the fact, the bromide of potassium in solution, (see *formula* 1, *tea*-spoon dose,) in two or three grain doses, given every three, four or six hours at first, and then once or twice a day, is a capital remedy. Some calcined magnesia and rhubarb in small doses, every few days, is also an aid. *For the fit*, ice to back of neck, and feet in *hot* water, and quickly done, is all important. The state of the gums, the diet, and gastro-intestinal condition must be looked after and set right. If there is plethora or hyperæmia of the brain, clip the food, and dissolve a grain of tartarized antimony, so that the child shall get, in repeated broken doses, all of it in three days, with magnesia and rhubarb laxative every other day. Then the bromide can come in play to confirm a cure by preventing the predisposition.

### *Epilepsy.*

In the treatment of all diseases we ought to have some distinct idea of the cause or *pathological condition* on which the disease depends. In epilepsy, as in many other affections, it is extremely

difficult to come to a satisfactory conclusion; but still it is our duty to go as far as facts will warrant. At the outset I will remark that most authors who have written on epilepsy agree in saying that the brain is in a state of congestion during the fit; while others, a few, take directly the opposite ground generally, or as regards many cases.

*The causes of epilepsy* are extremely various, and sometimes mysterious. First, we have hereditary predisposition; *mal*-nutrition of the great nerve centre at the base of the brain, or *malformation* of the cranium, or its contents; or diseased changes in the structure of the substance of the brain or cord, as undue hardness or softness, or bony pressure by exostosis; or from injury of the head or spine; or from tubercle, abscess, or effusion; or soft tumor pressing upon some part of the nerve centres; or albuminaria, or even from too plethoric a state of the blood-vessels of the head, (*where there is vaso-motor debility*,) or it may arise from any of those causes that can determine an excess of blood to the head, with increased impetus, or prevent its free return from thence; as the emotions and passions of the mind, such as joy, grief, fear, terror, anger, sympathy, venery, and intense solicitude, or study, or protracted suspense; or from sudden or protracted cold applied to the lower extremities; or over-violent exercise; intoxication by spirituous liquors, tobacco, or lead; or from excessive evacuations, or their sudden suppression after a long continuance; or from an *aura*, as "reflex causes," such as irritations from worms, calculi, or dentition; dyspepsia, gastralgia, or other morbid influence through the solar plexus of nerves; suppressed catamenia, utero-gestation, parturition, excessive or unnatural venery; or other irritation through the pelvic plexus; as also from traumatic causes, and from malaria; and lastly, the state of sleep when too long indulged in.

So varied in its causes, conditions, and character, varied must be the prescription, or combination of prescriptions, to cure any of the heads of this hydra-headed monster, *epilepsy*. But the grander question that arises here, is not so much what excites the attack, as whether disease be present; and as to what that disease is, which, either by being seated in the brain, or cord, or

by producing a blood-crasis, tends directly to allow or produce the convulsion.

In studying this affection we may find often, as a link in the chain of morbid catenations, the hysteric, or choreic, cataleptic, or other slightly nervous manifestations, which, from very little beginnings, if not checked, or cured, lead on and up to the full development of the terrible disease of epilepsy. This connected morbid chain of nervous derangement may, when further along, be traced, even as epilepsy itself, in something like the following order, or *degrees*, subject to a variety in the number, intensity, and succession of the symptoms, which we may divide into some half dozen classes: —

*Class* 1. The *fit* consists simply in a turn of pain or heaviness of head, (occurring from time to time.)

*Class* 2. The fit is termed the *petit mal*. There is a momentary loss of sense, but not of voluntary motion; a transient suspension of consciousness, a slight twitch of some muscles, with coma, and quickly all is over. And we might make another class of these, where there is a loss of sense for several minutes, but not of voluntary motion, the patient appearing like one in a dream, or in a state of somnambulism.

*Class* 3. The fit consists in a loss of both sense and sensation, and voluntary motion; continuing so for a long time, and recurring, perhaps, at shorter intervals, with palpitation of the heart, but showing no other affection of the voluntary muscles. In these stages the patient will sometimes talk for a while incoherently.

*Class* 4. The *fit* consists in loss of sense and voluntary motion, with palpitation of heart, and a rigidity of certain muscles, particularly of the extensors and those used in mastication, while others are not at all affected. In this stage of the disease there frequently comes in the *globus hystericus* — a symptom thus so graphically described by Dr. Mansford more than forty years ago. This is sometimes attended with crying or laughter.

*Class* 5. The *fit* of this class is characterized by an occasional transitory ascendency of the flexor muscles over the extensors, producing twitchings, but of little violence, with some or all of the appearances mentioned in the foregoing classes.

Slight convulsions now occur, affecting the muscles of the face and eyes. These aggravated symptoms are frequently ushered in by violent or long-continued rigors, or else the paroxysm terminates with them. Sometimes the rigors alone constitute the paroxysm or fit.

*Class* 6. *The complete fit of epilepsy* (and all in the five classes just mentioned are epilepsy or epileptic) is either instantaneous and without any premonition, or there is, as a forerunner, a sensible *aura*, of which the patient is conscious, and can give an account, or cannot from loss of memory. The chief manifestation of this disease consists in recurring attacks of sudden loss of consciousness, attended with convulsive movements. The person falls to the ground without thought, without feeling, and without the power of voluntary motion, uttering, usually, a short, piercing cry, and then a fearful muscular struggle follows. The head is twitched this way or that; the mouth is distorted, the lips covered with foam; the arms rigid, and hands clinched, are thrown about with force; the legs are outstretched, stiff, with heels apart, and the great toes towards each other; and during this fearful convulsive struggle, the tongue is liable to get between the teeth and become severely bitten, while the teeth are repeatedly ground together with great violence; the eyelids are but half closed, the pupils usually contracted, and *always insensible to light*. This is diagnostic of this affection from hysteria and from the feigned fit; for in those affections the pupils must contract when exposed suddenly to a strong light, and they must dilate when the light is withdrawn. Gradually the struggle and convulsive movements are less and less, and soon cease altogether, and the patient passes into a deep sleep, from which he, by and by, wakes up fatigued and exhausted, and dull in intellect; and after a few hours even these symptoms disappear, and there is a return of usual health, to be sooner or later broken in upon again by another paroxysm.

But every paroxysm, even in the same case, does not always present the same phenomena, nor run the same course. It may be followed by hemiplegia, due to a congestion of the brain during the fit. This palsy is, however, usually very transient, and disappears in a few days. Sometimes there is left a debility

of the throat, a loss of voice, or abdominal tenderness. In the interval between the seizures the patient is not perfectly well. He is more irritable, and soon is affected in memory and mind, and finally may show decided mental degeneracy. Epilepsy is said to be either central or peripheral; I believe it is frequently both, with one or the other more or less preponderating; and for this reason we are to carefully study every case.

It is a very curious old proposition that the *torpedo* fish affords a proof, that the same animal, or, in other words, the different parts of a living animal, may retain opposite states of electricity in a strictly physiological sense. Although in health, and surrounded by what we generally believe to be conducting media, the *motions of the electric currents in the living animal*, so evident in this coarse and strong specimen, are independent of the operations of the laws which govern them in other situations, as in metals and on insulators, and are subject rather to the control of the *vital force*, or principle of life.

According to this principle, the brain is the organ appointed for the formation, retention, and preservation of this fluid; or to act as one pole of it, where, while in a state of health, it is completely controlled by the will and the balancing laws of vitality, in opposition to its natural tendencies in all bodies excepting the living. In a figure, the brain would thus sustain to the body, the relation of the gunner with his lanyard and percussion cap to the charged piece of artillery.

It has thus been assumed, by many high authorities, that epilepsy, with and without organic disease, has this feature of *a gradual accumulation, and then a sudden explosion of nervous energy as an equalizing of the general nerve polarity and circulation;* consequently *one* of the principal aims in its treatment is to forestall and prevent these phenomena. The object is supposed to be attainable by either of two ways. The one consists in keeping up, at short periods, repetitions of *involuntary* actions of the muscles, for the purpose of using up or working off the redundancy of nerve force, aided by the internal use of nux vomica *in very small doses*, daily repeated, and for a long time, together with electro-magnetism externally applied, as *down* the

back, or to the stomach, or over the body and limbs, in a prevailing down-running direction.

Another method, less heroic, and perhaps better suited to milder cases, consists in almost ceaseless but moderate muscular exercise in the open air, combined with simple and careful diet. Dr. J. Paddock has reported very many successful cases, showing that by these methods, well chosen, he has succeeded in warding off the attacks indefinitely. I have no question that cases can be selected where such a procedure could work a cure.

Again, the principle of cure for epilepsy, from this stand-point, and with these views, has been conceived by some distinguished men to consist in simply aiding the nervo-electrical action of the body as a whole, so that the natural rule of action, or physiological habit, might be reëstablished by nature itself. As early as in 1819, Dr. Mansford, of England, proposed to accomplish this object by *establishing* a weak inverse electric current, and *allowing* a continuous direct current from the head towards the lower extremities, and thus completing artificially the animal electric current by good conducting media, aided by a single pair, that was to be worn all the time.

This was to be a single pair, of zinc and silver, with a long insulated connecting wire, "so placed that a negative point should be established as near the brain as possible, while a positive pole was on some distant part of the body or limbs, which should preserve these opposite states unceasingly by being kept constantly in action. A portion of the cuticle of the size of a sixpence must first be removed by means of a small blister in the back of the neck, as close to the roots of the hair as possible, and a similar portion on the inner side of the knee, as the most convenient places; then to the wound in the neck a plate of silver, varying, according to the age of the patient, from the size of a sixpence to that of a half crown, was to be applied, having affixed to its back part a handle or shank, and to its lower edge, and parallel with its shank, a small staple, to which the insulated conducting wire was fastened. This insulated wire descends the back till it reaches a belt of leather buttoned around the waist; it then follows the course of the belt, to which it is attached, till

it arrives opposite the groin on the side it was wished to be used; it then passes down the inside of the thigh, to be fastened to the zinc plate by the knee in the same manner as to the silver plate above."

The apparatus so contrived was thus applied: a small bit of sponge moistened with water, and corresponding in size to the blister on the neck, was first placed directly upon it; over this a larger piece of sponge, of the same size as the metallic plate, also wetted, was laid; and next to this the plate itself, which was secured in its place by a strip of sticking-plaster passed through the shank on the back of the silver plate. The zinc plate was fastened in the same manner; but in place of the second layer (of sponge) a bit of muscle was interposed of the size of the zinc plate; that is, a small slice of sponge moistened in water first, then the piece of muscle, also wetted, followed, and on these was placed the plate of zinc. The apparatus thus arranged would continue in gentle and uninterrupted action for twelve or twenty-four hours, according to circumstances. This last is the longest period it should be allowed to go unrenewed; the sores require cleansing and dressing; the surface of the zinc becomes covered with oxide, which must be removed to restore its freedom of action. This may be done by scraping or polishing; and it is better if done twice a day. Care must be taken that there is no irregular action, no failure of action. The sponges on the skin must be always moist and clean, the metallic contacts must be perfect, and not so as to unhook, or make and break the current at any time by the motions of the body.

The sore under the silver plate is always inclined to heal up if the pressure be removed or slackened; but a slight touch of the potassa fusa will reëstablish it, with only a momentary uneasiness to the patient. The other sore, which is acted on by the zinc plate, occasionally shows a tendency to become irritable and a bad sore. When this occurs the sore can be washed with an astringent, and nicely guarded on its edges by adhesive plaster, leaving only a small hole in the centre of the sore exposed. The hard edge of the zinc plate will sometimes, if suffered to press upon the surrounding skin, excite irritation, or produce eschars. To obviate this contingency, the bit of fresh beef mus-

cle may be cut thin, but rather larger than the metal, so as to act as a cushion under and around it. All these points attended to, and the apparatus is easy and comfortable. Dr. Mansford, having had much experience, says it may be worn thus for any length of time necessary to effect a complete cure. But the results of my own experience in this, are mostly negative.

*Treatment of Epilepsy.* — First, to this end, we should divide these patients into two classes. As a general principle, in the treatment of epilepsy and kindred affections, we are to call to our aid, understandingly, some of *the most powerful alteratives of nerve nutrition and action*, whether that be electricity, so applied as to be simply nerve-toning, or also for *reflex effect* on the centres; or strychnine, iodine, manganese, iron, phosphorus, and sulphur; or arsenic, quinine, blisters, setons, moxa, firing-iron, or shock from the double-bath (of first hot water and then the dash of the cold) for one and the larger class. And these nerve-toning or polarizing remedies must be prepared for, by removing every conceivable existing cause, and then aided by air, sunshine, and exercise, a cheerful mind, and good, plain, regular diet, with strictly regular habits, constant occupation, and short nights. Very early and regular rising is important for an epileptic.

But for the other smaller class of strong, vigorous, or plethoric cases, on the contrary, we are to resort rather to the *depolarizing* methods and medicines, as the daily warm bath, or sponge bath, or ice to the spine; silver, antimony, mercury, bromide of potassium, belladonna, conium, stramonium, hyoscyamus, ergot, aconite, nicotine, and electricity, as a primary current; or the *extra* or faradaic current, *applied only in a steady down-running direction*, as from top to bottom of spine, or to the umbilicus, (see *Rule* 14, page 469,) aided by abstemious diet, no stimulants, and very moderate exercise. Of course, in some cases where complicated, or partaking in some varied degrees of the two classes, they will require a combination of the two classes of remedies. If there is secondary syphilis, scrofula, worms, albuminaria, or what not, the intelligent physician will prescribe *pro re nata*.

The treatment of epilepsy must, therefore, necessarily be

eclectic. The physician who enjoys the best general and minute knowledge of his profession, and who exercises skill in its application, will also be the best qualified to deal with this very peculiar affection. Whoever reads these pages may believe th I neither know of, nor do I believe in, any one remedy, as a specific for epilepsy.

A case of epilepsy is reported by Dr. Paget, in a laboring man, who had been subject to regular, fully-developed fits for some time. Prior to the appearance of these regular epileptic convulsions, he had been for eight or nine months subject to frequent bursts of unmeaning and uncontrollable laughter, which came on day after day, and lasted about a minute. They were quite involuntary, and without any apparent cause. Dr. Paget, who has had the greatest experience in this disease, thinks these were essentially abortive epileptic fits. In the case of this epileptic man, for some months, the laughing spells, and then the fits, had been preceded invariably by an aura, sensibly felt, which commenced on the abdomen, and rose up to the throat, when the attack would immediately set in. Blisters, repeated over and about the umbilicus, with bismuth, hyoscyamus, and magnesia, internally, diminished the fits, until he had no more.

In young persons, where the mild, epileptiform symptoms appear, such as giddiness, or vertigo, or *petit mal*, it is all important to be well acquainted with this combination of symptoms, — of the slighter manifestations of this insidious disease, — because of the greater efficacy of medicine in the early stage of the affection. The patient may have repeated spells of reeling, or suddenly stops, or drops what he holds in his hands. For a second, or so, he is simply unconscious. If he is standing, perhaps he will try to sit down; if speaking, he stops for a moment, as if there were an intellectual eclipse. There is a slight paleness, and he sees and hears perhaps imperfectly. If he is walking, he stops or slows his pace; and if the attack is considerable, he turns his head to one side, and perhaps exclaims, "murder, always something," or the like, and if instantly spoken to, he cannot reply; but in a moment more he can hear, understand, and speak. These epileptiform symptoms are also betrayed in the countenance; not only by the paleness, but there is also a look

of surprise, and a very fixed stare, caused by a tonic spasm of the eye muscles. It is believed, now, that vertigo is always attended with a convulsive action, which is partial and rapid, it is true, but generally tonic, and affecting one or many muscles.

In the treatment of such like cases much confidence is placed in belladonna or atropia. ℞ extract of belladonna half a drachm, with extract of gentian or camomile q. s. — M. Divide into sixty pills. One pill to be taken daily for a week; then the dose may be two pills a day, which must not be exceeded. I frequently prefer *formula* 12, given once a day. The pills should be alternately taken and discontinued for a fortnight at a time, for several months, and a year or more if necessary. This prescription might well be alternated with the bromide of potassium, for a fortnight each. Indeed, this is frequently my own practice, and it has been attended with good results.

A case of epilepsy, of a year's standing, in a strong man, who had always been well, but received a blow on his head from a fall, and had fits following, which set in some weeks after the accident, I cured by giving the iodide of potassium in ten-grain doses, twice a day, and applying the primary current from Daniell's, twenty-five cups, down the spine for fifteen minutes, two or three times a week, for six weeks. He has had no fits now for over three years. This would be the best plan to pursue for epilepsy in constitutional syphilis.

There are some interesting cases reported by Dr. Reiner, who says he has succeeded in breaking up the fits by quickly compressing both carotids until the complete cessation of the pulsation. This, if practised repeatedly on the first appearance of precursory symptoms, where they occur, always has the effect to shorten, lessen, and finally to break up the fit; meanwhile, there was a gain of general condition, both mental and bodily.

In the *rational treatment* of epilepsy, we are to see to it from another stand-point, that exciting bad habit, or other voluntary causes, are removed, if any such can be detected; next we must seek to correct any faulty organ or state of the system, as plethora, anæmia, debility, syphilitic taint, worms, or *aura;* then we are ready to proceed to treat the undue excitability of the nerve

centres. At the head of the list we place electricity, when judiciously employed, which may be, and usually ought to be combined or alternated with other appropriate means. In ordinary chronic epilepsy, prescribe something like *formulæ* 1, and 12 or 23, and order it to be long and regularly taken.

Active purging, in some subjects, is a wonderful aid. In others, we see the need of toning and invigorating, by every possible means. For these prescribe something like *formulæ* 5, 6, 9 or 19, 10, 20 or 24. With some such prescription for other cases, we may advantageously combine silver, zinc, or tannin, or the cod-liver oil; and electricity, applied over the abdomen and vital organs, while the patient is lying on his back; thus selecting a tonic, sedative-tonic, or an irritating tonic, as the case may require. In very violent, or frequently recurring fits, opium or morphia, as *formulæ* 2, 23, 24, or 28, with ice to the upper spine. But ice is not indicated unless there is marked congestion, or a sthenic state. But electricity, run steadily down the back, or down the limbs, can tone down without depressing.

If there is a uterine derangement, it must be corrected; and I have found something like *formulæ* 4, 17, or 22, can well be adapted to some such cases. If there is a syphilitic taint, prescribe *formulæ* 7, 13, or 24, (to be regularly and persistently taken,) with moderate diet, and perfectly regular habits. If there is a morbidly irritable urethra, or prostate, gently introduce a number six insulated zinc sound down the urethra and through the prostate, stopping just before the sphincter; or, entering the bladder, and then withdrawing the instrument, so as to rest its metallic tip within the urethra, and as near the bladder as possible, for some ten or fifteen minutes, with *the primary current of one cup*, run from the sound or catheter, by holding the tip of the positive conductor in contact with the flat end of the sound, while the negative electrode is a moist sponge, and tucked under the thigh. This should be repeated every other day, or once or twice a week.

*Malarious Epilepsy.*—This affection occasionally occurs a long time after a malarious infection, which may, or may not, have manifested itself by paroxysms of ague, or fever; so that we may see this kind of convulsive seizure as the sequel, or as the

only active symptoms, of the infection. In these attacks there are no premonitory symptoms; no sensation or warning; no syncope; but the body drops as if shot. There may be no febrile symptoms on the one hand, and on the other it differs from eclampsia in its mode of origin, and in the character of its symptoms. The attacks are periodical.

The pathology of this affection may be looked for in the *non*-nutrition of the centre and base of the brain, and in the morbid condition of the blood, as a consequence of deficient oxidation. But we must also bear in mind that there are other sources of neurosis: slow lead-poison, or protracted and unceasing mental toil, and excess in venery, are some of them. Several of these combined, must prove a still more potent cause.

What is remarkable, as in other forms of epilepsy, the extremes of complexion are seen; as in some, pallor, or a bilious skin; in others, fulness, bloat, and excess of color sometimes exist; but there is always extreme muscular debility. Thus, you see, it closely resembles true organic epilepsy, but, unlike that, it is more amenable to treatment: indeed, it is curable by quinine and faradaism, and such other nerve and muscle tonics as usually cure the so-called malarial diseases. But it may sometimes be necessary to remove the patient from the source of the cause before a cure is confirmed.

Dr. Marshall Hall maintained that the spinal system is the *source and seat* of all the classes of *convulsive* diseases. There are, he says, several important physiological facts to be noted, (and here we condense his statements,) viz.: —

1. If we puncture, or lacerate, or otherwise injure the cerebrum or cerebellum, or the cerebral nerves of special sense, in every possible manner, we observe *no results — no phenomena*, no expression of pain, no excited movement. The cerebral system, in all its parts, is, *in this respect*, inexcitable.

2. If we touch any part of the spinal system, and especially the spinal centre, with the mere point of a needle, if ever so slightly, then there are immediately excited muscular movements, spasms, or convulsions. The spinal system is, in all its parts, *excitor — excito-motor*. These important facts constitute, according to him, the foundation of all our knowledge of the

diseases of the nervous system, and are the very *source* of all *diagnosis* in regard to them. These facts hold good in regard to the living human body. By experiment and by observation, then, we are led to these conclusions: —

3. No lesion of the cerebral system, *if limited to the cerebrum*, can be attended by spasm or convulsion.

4. No structural lesion of the spinal system, short of absolute destruction, can possibly occur without exciting *spasm* or *convulsion*. If the destruction is complete, then there is palsy.

If, in affections of the cerebral system, we observe spasm or convulsion, it is because it is *not limited*, in itself or in its effects, to the cerebral system. Thus congestion of the centre of the cerebral system may, as in hanging, become extended to that of the spinal system, and then spasm or convulsion appears.

Again, affections of the spinal centre may consist of mere light or gently-applied *pressure*, not in absolute lesion of tissue; and then paralysis, not spasm or convulsion, will be observed. Or it may consist in sudden or violent *shock*, or in utter destruction; and then, I need scarcely say, paralysis, and not spasm or convulsion, will occur. All this we have seen demonstrated by experiment; all this you will see again and again in your observation in clinical practice, and especially in the surgical wards. What a means of *diagnosis*, then, have we obtained by these simple physiological facts! How has physiology become our guide in practice! I have thus explained to you how disease of the cerebral centre may, *by pressure downward*, affect the spinal centre. But another question arises — How does a disease of the spinal system, as a pure convulsive malady, affect the cerebral? — for such is a frequent event, as we observe in epilepsy. Marshall Hall says,—

"Notice what occurs in the most *marked* cases of this dire malady. The head becomes fixed, or there is *torticollis, by the action of the muscles of the neck* — a trachelismus; the jugular and other veins of the neck are compressed; the capillaries of the neck, the face, and of the intracranial structures are congested; the veins swell, the arteries throb; the *cerebral centre now* becomes implicated. *All is intelligible; all is explained!*

"Affections, then, of the centre of the cerebral system are extended to that of the spinal system — to the *medulla oblongata* by the *downward pressure;* while affections of the spinal system are extended back again to the cerebrum *by trachelismus!* That *all* this is so is demonstrable. That it is *always* so, is, perhaps, what I ought not to assert. And does it not constitute a beautiful specimen of the *physiology of disease?* Such is the whole of our recent views of *epilepsy*, and of the *class* of convulsive diseases as observed in the clinical wards.

"Observe, now, with me, an experiment or two. I have removed the cerebral centre of this frog. Its spinal system is still most lively and energetic. I take and rub the toe between my thumb and finger; you observe the almost convulsive movements produced; I now touch the upper part of the spinal centre with this needle, and you see the animal is thrown into the most violent convulsions! Now, these experiments are *types* of disease; they are the types of epilepsy and other convulsive diseases. The first experiment is the type of *eccentric* epilepsy. The second experiment is the *type* of *centric* epilepsy. The first was induced by an excitant applied to a part of the spinal system at a distance from its centre; the second, to that centre itself. So is it in epilepsy. So is it in convulsive diseases generally in the human family. Do not these simple and illustrative facts interest you? They are of the deepest interest. Do you not now perceive *how* dentition, and gastric, and enteric, and uterine irritation may excite spasms or convulsions, or even epilepsy?

"You see, again, the violent convulsions which I excite by touching the spinal centre of this frog by this needle. Such is the dire state of things in centric epilepsy, whether this be of organic *origin*, or have been organic in its *course;* whether it be congenital on the one hand, or inveterate on the other. The cases of epilepsy which occur in private practice are, for the most part, of the former or eccentric kind, and are *curable;* however, for many reasons, they are difficult of cure."

And now you perceive *in what sense* epilepsy may be regarded as a cerebral disease. Cerebral in its very *origin* it can never be. It may be intra-cranial in its origin, because within the

cranium there are many tissues, as the membranes from which cisodic nerves arise — many such nerves, as the fifth pair especially, pursuing there a part of their course; and the *medulla oblongata* also — all of which may be excited by the presence of an exostosis, a tumor, or a variety of causes. But I repeat, that no disease of the cerebral centre, limited to that centre in itself, and *its* effects, does or can produce epilepsy.

Exciting causes of epilepsy are, then, first — the spinal *system*, the neck — the encephalon. Such are the order or *links* of this chain of pathology. There remains another, to which I must now draw your special attention: it is the *medulla oblongata*, with its *pneumogastric nerve*. I have already adverted to laryngismus as giving to epilepsy, and to convulsions generally, its most formidable character. This form of laryngismus is *spasmodic* or *convulsive*, and excited through the spinal system.

But there is another form of laryngismus to which I refer. After a severe epileptic convulsion, the patient is left in a state of *coma*, or, as it may be termed, of *simple apoplexy*. This condition may prove fatal. The respiration becomes stertorous, that is, there is laryngismus. But this laryngismus is very different from that just before described. This is less complete, but more persistent; it is, indeed, permanent. Some one has said, in rather familiar phrase, "the patient snores his life away." This laryngismus is *not* like the former, which was spasmodic, but is *paralytic*. It is owing to compression or congestion — an apoplectic state — of the medulla oblongata, and *paralysis* of the pneumogastric nerve, in which every branch of it, as well as the recurrent laryngeal, is implicated. There is, then, complete *apoplexy* of the medulla oblongata, and *paralysis* of the pneumogastric nerve!

What phenomena do we observe as occurring in the coma, or simple apoplexy, seen after a severe epilectic seizure? We see *paralytic* laryngismus, impeded respiration, augmented apoplexy. We also observe — or rather I have observed — a *diffused bronchial rattle*, the *effect* of *paralysis* of the bronchial and pulmonary nerve branches from the pneumogastric!

Here a most interesting phenomenon presents. The cerebrum is *not essential to animal life*. How, then, does apoplexy, simple,

cerebral apoplexy, destroy life? It does not do so. Apoplexy only destroys life indirectly, as when by its congestion from downward pressure it implicates the medulla oblongata and its pneumogastric nerve. It is by the apoplexy of this medulla, and the paralysis of this nerve, that life is finally, in effect, destroyed!

Generally, such a patient dies of *paralytic* laryngismus, or of laryngeal asphyxia. From this danger the patient may be rescued by early tracheotomy. But if the tracheotomy *be* performed, but performed too tardily, the patient, however saved from *laryngeal* asphyxia, dies, after all, of *bronchial* asphyxia. And there are other branches of the pneumogastric nerve that suffer — the cardiac and the gastric. The heart and the stomach participate in the partial or complete paralysis of the general pneumogastric. If the physician observes palpitation as a symptom in some cases of epilepsy, this is explained by being aware of the excitement of the cardiac branches of the pneumogastric. In other cases there are hickups, eructation, acidity of the stomach, the effects of excitement of the gastric branches of this composite nerve, viz., the pneumogastric. Now, as in these cases there is a *morbid action* in the heart and stomach, so in deep epileptic coma, there is *failure* of the powers of these organs.

The pneumogastric nerve is more involved in epilepsy than it is in other convulsive diseases. For mark, all the phenomena just described as observed in the former, are again met with in the latter, only, of course, modified by the exciting causes and the conditions of age and sex.

In infants there is the same or similar action of the muscles of the neck, and of the larynx, and of respiration. In puerperal convulsions the symptoms are identically those of epilepsy. There is a form of epilepsy which I have not yet here noticed. It is the *epilepsy syncopalis*. The patient, instead of turning purple, (with congested face,) turns pale and ghastly. Sometimes this syncope is *fatal!* So it is in the *laryngismus stridulus* of infants. The little patient not unfrequently dies suddenly — too suddenly to be the effect of asphyxia. Such a case is cardiac syncopal.

The laryngismus stridulus is often excited by *enteric* irritation.

This is also frequently attended by fret of the bladder. Epilepsy is induced by enteric and by uterine irritation, and is sometimes attended by involuntary evacuations of the bladder, rectum, &c. The urine is frequently found morbid in both cases.

On the treatment of all convulsive diseases, and epilepsy in particular, M. Hall advises that excitement and irritants must be, as far as possible, avoided. The morbid condition of the blood and of the organs must be remedied. A low posture and deep sleep must be carefully shunned. *The neck must be cautiously guarded against a tight collar*, &c. This is all perfectly sound in therapeutics, however questionable may be some points in his theory.

M. Flourens has shown that while superficial sections of the *corpora quadrigemina* produce no other effect than the impairment or loss of vision, deep sections produce general convulsions. "I have been desirous," he says, "of ascertaining whether the parts within the cranium, if excited by the stimulus of galvanism, would give rise to any phenomena similar or analogous to those produced by galvanic stimulation of the spinal cord. Accordingly, I determined to subject them severally to the action of the magneto-electric rotation machine — a most convenient instrument for physiological experiments."

The trials were performed on rabbits. "I took the spinal cord first; here we had the well-known tetanic effects to which I have already frequently referred. Next I tried the *medulla oblongata:* the effects of the stimulation of this organ were much the same as those produced by irritating the cord. I then tried the *corpora quadrigemina* and the *mesocephale*. Having passed fine brad-awls into the cranium, in such a direction as I had previously satisfied myself would lead to this organ, I subjected it to the influence of the machine; general convulsions were produced, of a character essentially different from those which resulted from stimulating the spinal *cord*, or the *medulla oblongata*. They were combined movements of alternate contraction and relaxation; flexion and extension affecting the muscles of all the limbs, of the trunk, and of the eyes, which latter rolled about just as in epilepsy.

"On inserting the awls into the hemispheric lobes of the brain, still different effects were produced by the application of the electric machine. I could observe nothing like true convulsions; but slight convulsive twitchings of the muscles of the face took place, which were no more than what would be caused by the stimulus of galvanism acting upon the nerves of the face. These experiments, which I have repeated several times, and each time with like results, seem to denote *that convulsions are modified* according to the part of the cerebro-spinal axis which is primarily excited: if it be the spinal *cord*, they are tetanic; if the *medulla oblongata*, they are tetanic likewise, other parts being involved; if the *corpora quadrigemina* and the *mesocephale*, they are epileptic; if the cerebral hemispheres, you scarcely have any convulsions, but slight twitchings of the muscles."

Dr. Weber, in his excellent essay on muscular motion, published in Wagner's "Handworterbuch" of physiology, refers briefly to similar experiments performed by himself on the brain of a frog, and leading to the same results; and he draws this conclusion, that "the *tonic* convulsions, as trismus and tetanus, are the effect of disturbance of the functions of the spinal cord; whilst the *clonic* convulsions are due to derangement of the functions of *certain parts* of the brain."

Thus, then, I come to this conclusion, respecting the parts of the nervous system which are directly concerned in the production of the epileptic paroxysm. The part of the encephalon primarily disturbed is the hemispheric lobes; if the disturbance do not go beyond a certain point, the phenomena are limited to simple loss of consciousness and impaired intellectual action, with more or less *sopor*. But if the disturbance be considerable, then the *tubercula quadrigemina* and *mesocephale* become involved, and *epileptic convulsions* are produced. If the disturbance of this centre be very great, the *medulla oblongata* and the *medulla spinalis* become much excited, and the convulsions are complicated with a good deal of the tetanic character. House painters or others exposed to the contamination of *lead* are apt after some time to fall into a fearfully cachectic state, of

which a principal feature is the deficiency in red particles of blood. I have seen several persons, under these circumstances, become epileptic shortly before death, and, in fact, die in consequence of the violence of the epileptic paroxysms. All these are striking instances to show how blood, when deficient in quantity, deficient in one of its most important staminal principles, (the others, perhaps, not being quite normal,) and, perhaps, contaminated by the presence of some foreign noxious principle, tends to the production of the epileptic state.

Experimental physiology supplies us with very striking facts, to show that simply an *insufficient* supply of blood to the brain is very apt to occasion epileptic convulsions. Every one who has witnessed the slaughter of sheep, which is effected by dividing the great arteries in the neck, must have observed the strong convulsions which so frequently precede death in animals killed in this way. All animals killed by loss of blood exhibit the same phenomena precisely, and die with convulsions of a more or less violent kind. Such facts suggest the *rationale* of treatment for cure, which can be done, in some degree at least, by electric currents. If we follow the views of Dr. Marshall Hall, we find that the diseases of the spinal system exist under several forms, which admit generally of being reproduced in experiments for the purpose; and one great advantage in the study of experimental research in the spinal system, is, that there are thus frequently presented the "*types*" of its diseases.

"In general," he says, "the diseases of the spinal system occur under the form of *spasm*, of *paralysis*, or of the two combined, viz., *spasmo-paralysis*. They are all primarily affections of the excito-motor muscular system, to the exclusion of the sentient or cerebral system — a singular confirmation of a physiological doctrine, that these two systems are totally distinct from each other."

Generally, spasm consists in *irritation* of nervous tissue, still retaining its normal structure; whilst paralysis implies a *lesion* of that structure. But the structure of the nervous tissue must be viewed under several aspects; thus this tissue may be

injured by being lacerated or bruised at any given point; but it may be strangely injured in a given point, by injury inflicted at a distance, through the means of *shock*. In this manner spasm is apt to lead to paralysis, and for the obvious reason that this peculiar lesion is of the most intimate or atomic character, unlike the division or separation of its atoms by laceration, &c.; the paralysis, or spasmo-paralysis, so induced, is less persistent than in the latter case.

This remark leads me to the subject of the excito-motor power itself, on which all the movements connected with the spinal system depend. This power may be diminished or even suspended in its energies; it may be also greatly augmented; in which case there is proportionate *susceptibility* to impressions, and to excited actions the results of those impressions.

The former state of things is induced by all agents of such violent character as produce shock; the latter is induced by peculiar agents, of a chemical or physical character, which act more gently on the nervous structures. The same identical agent may produce either of these effects, indeed, according to its degree. Thus too large a dose of strychnine speedily destroys all excitability; a very minute dose, on the contrary, induces the most extraordinary phenomena of augmented excitability which we can witness. The action of the electric current is precisely similar; a very mild current produces purely physiological effects; too strong a current soon induces destruction of the excitability of this part of the nervous system. The first effect of decapitation (of shock) in a frog, is supension of the excito-motor power; the second and ulterior effect is, or is supposed to be, an *augmented* susceptibility to activity of this vital agent. Electricity, heat, and the class of agents called *stimuli*, generally, may be employed so as to act as augmentative or destructive of the excito-motor nervous power.

As an example of these effects, I may mention, for the benefit of those who have not performed an experiment, that *immediately* after decapitation of the frog, no reflex actions are produced, on irritating the foot; it is here diminished excitability, the effect of shock. On administering a minute dose of strych-

nine, on the contrary, the touch even of a feather induces reflex action of a tetanic force and character. Marshall Hall says, —

"From experiments we learn that this augmented susceptibility or excitability may exist in *force*, without existing in *action*. A frog may be under the influence of strychnine, yet, if not actually *excited*, it may remain quiescent, relaxed in posture; it is tetan*ode*, without being tetanic, affording a *type* and idea of certain diseases of the spinal system of the deepest interest — one on which the *rationale* of the symptoms and the adaptation of remedies alike and equally depend.

"Now, in this point of view, the effect of strychnine on the frog presents the *type* of hydrophobia. In both the *blood* is poisoned; in both the spinal system is in a condition of extremely *augmented excitability*, without being necessarily *excited*. Avoid all excitation, and the frog recovers. Apply excitation of the mildest character, continuously, and the frog speedily dies; here an experiment accurately presents not only the *type* of the malady, but of the *treatment*.

"In this experiment, as in hydrophobia itself, we have two conditions, one of *excitability*, the other of *actual excitement*, according as excitation is averted or admitted. I propose to designate the former condition by the termination *ode*, the latter by that of *ic*. The frog, unexcited, is still tetan*ode;* excited, it becomes tetan*ic*. The patient affected with hydrophobia is hydrophob*ode;* is he necessarily hydrophob*ic?* The former state admits of recovery; the latter soon destroys.

"In this point of view we may consider other diseases of the spinal system. The patient affected with tetanus is not necessarily tetan*ic;* he is only tetan*ode*. If excited, he dies. What if he were or could be preserved absolutely from all excitement? He dies of violent and exhausting spasms. These spasms are *reflex* actions; reflex actions are necessarily *excited*. Remove all excitation, and the spasms — that is, the cause of death — would be averted."

In like manner, the newly-decapitated snake is *full* of excitor and motor power, yet free from movement, unless an excitant be applied. So also of certain forms of convulsive disease in

infants and in adults. The patients are spasmat*ode* or spasmat*ic*, according as they are excited or preserved from excitement. The difference throughout is that of the *predisposition* to or actual *condition* of spasmodic action; or that of ex*citability* and ex*citement*. The former may subside, the latter destroys.

The further difference between hydrophobia and tetanus is, that the former is induced through the medium of the *blood*, the latter through that of *an incident nerve*. Of the former, the frog affected with strychnine presents the exact *type;* of the latter I doubt whether we possess an *exact type* in any experiment. No experiment has been devised, to my knowledge, to induce augmented excitability of the spinal system through the medium of an incident nerve or nerves, or of any part of the spinal system. It is said that the *decapitated batrachian* is more excitable than the whole or entire animal. But this I think is a mistake. The effects of excitation are *controlled* by efforts of volition in the perfect animal, but are *uncontrolled* in the decapitated animal. The difference, therefore, is rather apparent than real.

*Epilepsy*, according to authorities, has its primary source or "first cause" *more frequently* in the obviously disordered nutrition of some of the more important organs, and it is most probable that the brain itself, or rather some *portion* of it, is implicated. This can result, moreover, from a great variety of causes, mental or physical; in any case, however, it may then long continue as a mere *disease of habit*, which electric currents may greatly aid in curing.

"The pathology of convulsive diseases, as now understood," says Dr. Todd, "seems to show that if the nervous disturbance does not go beyond a certain point, the phenomena are limited to loss of consciousness and impaired intellectual action, and this with more or less sopor. If, however, the disturbance be more considerable, then epileptic convulsions are produced. If there is a still greater or more profound disturbance of the *tubercula quadrigemina*, then the *medulla oblongata* and *spinalis* become excited, and the convulsions are complicated with a

good deal of the tetanic character. Looking, then, to the whole assemblage of *ganglionic centres* interposed between the cerebrum and the spinal cord, as on the one hand including the centres of sensation, and probably also of the consciousness of the cerebral operations, as well as impressions on the organs of sense, and on the other as forming the summit of the apparatus *from which* motions are directly excited, we cannot but think that they are the parts of the encephalon primarily affected, and that the affection of the hemispheres is rather secondary." Although the loss of consciousness and convulsive movements are usually combined in the epileptic paroxysm, the morbid action radiating upward into the cerebrum, and downward into the motor arrangements, either may therefore occur independently of the other. The loss of consciousness is evidently the primary and essential phenomenon in epilepsy; the disturbance of the intellectual functions is obviously secondary and accidental. The *superior ganglion* (pineal) is the focus.

When the epileptic paroxysm is the manifestation of a state of abnormal nutrition of the nerves in some part of the brain, which thus shows itself in an undue development of nerve force, it is, according to Dr. Todd, a disturbance of their nervo-electric polar state; and this, when it has attained a certain measure of intensity, manifests itself in the epileptic paroxysm, just as a Leyden jar, when charged with electricity to a certain state of tension, gets rid of its disturbance by a "disruptive discharge." This state of tension of the brain he regards as resulting "from the accumulation of some material in the blood, which, acting on the brain as a poison, excites this polar state, and this disruptive discharge, and so escapes from the system, leaving the brain sensibly free, until a fresh accumulation excites a new paroxysm."

The nature of the morbific matter, or condition of the fluids, which are found capable of being modified, and sometimes corrected, by the catalytical workings of galvanism, we cannot yet determine. But the resulting *fact* is strongly supported by the following opposite classes of facts, which are adduced for analogy, viz.: —

1. The influence of toxic agents in *producing* artificial epilepsy.

2. The frequent connection of epileptic convulsions, and imperfect elimination, especially by the kidneys, which, when in a still greater degree, is also attended with coma.

3. The correspondence between the paroxysmal character of epilepsy and that of other diseases called humoral, as ague and gout.

4. The introduction of certain animal poisons (as exanthemata) into the system can produce epileptic convulsions; and to these might be added evidences derived from cases of hydrophobia, hysteria, chorea, and tetanus, as occurring also in absence of structural lesions, and in still greater force by those strange manifestations of disordered excitement of the nerve centres which are manifested in *neuræmic* or hysterical forms of convulsions, which always baffle the sagacity of the best physician to satisfactorily account for, and that of the most skilful practitioner to cure.

The diagnosis of the hysterical form of epilepsy is mainly made out *by observing the suddenness with which the several forms give successive place one for the other*, as a choreic for tetanic, and this for epileptic, or paralytic, or perhaps passing off altogether. Thus the strange combinations or successions which they often present mark them from the more settled form of nerve disease that they so simulate.

Dr. Copeland, in his great work, says, "I have not given a *class* of *anti-spasmodics*, because there is really no such class of medicines that possess the property of directly arresting spasms." But probably he had not become familiar with the modern methods of directing the electric current through nerves so as to be an *anti-spasmodic*, as well as an *anti-paralytic*, — not by diminishing their strength, but by nourishing them, and fortifying their power of endurance.

Dr. E. Brown-Sequard is inclined to believe that epilepsy *consists* essentially in an exalted abnormal excitability of certain parts of the cerebro-spinal axis, and in a simultaneous loss of the control that, in normal conditions, the *Will* possesses over

the reflex faculty. He has shown that the same cause that produces the first convulsion in some muscles of the neck, the eye, the larynx, and the face, produces also a contraction of the blood vessels in the brain proper, and which contracti is necessarily followed by the loss of consciousness. MM. Turner and Kussmaul, led by somewhat different researches, arrive at the same explanation.

According to Dr. Brown-Sequard, there are other nervous affections that very often have the characteristic features of epilepsy, at least as regards their *production*. He relates a large number of facts that go to show and prove that, far more frequently than might be imagined by most persons, there are many forms of insanity, of vertigo, of hallucinations, of illusions, and also of ecstasis, catalepsy, hysteria, chorea, hydrophobia, tetanus, (lockjaw,) local cramps, and even that peculiar diffusible paralysis that is connected with insanity, which may be due to irritations "*starting*" from a centripetal nerve ramification that is frequently but slightly felt, or even utterly unfelt; that the suppression of this local irritation may as promptly as surely cure the patient, just as is done in cases of true epilepsy.

In accordance with this view, he advises that the precise condition of all the surface and organs of the body should be most carefully inquired into. If the unfelt *aura* starts from some part of the skin, or from some organ not deep seated, — as the testicle, for example, — or some part of the mucous membrane *near* the skin, either the first "*contractions*" in a fit, or the most violent, or the most prolonged, *are found in the neighborhood of the point of starting of the aura.* If no indications of this can be furnished by the persons who have seen the fits, Dr. E. Brown-Sequard advises, to apply a very powerful galvanic current, with dry electrodes, on the various parts of the skin, about the time *when the patient expects to have the fit.* He says he has in this way discovered the very "*point of departure*" of the aura that had been entirely unfelt by the patient, and undiscovered by the medical attendant.

If this test is resorted to, I would advise rather the employment of electro-magnetic or magneto-electric currents, as strong as the patient can bear, using metallic ball electrodes as *team*

*electrodes*, i. e., held side by side, and thus moved along over the suspected region, in the first instance, much as localized Faradaization; but if no aura is thus "scared up," then the appeal can be made through reflex action, and this can be greatly multiplied by widely separating the electrodes, using larger ones on moistened skin, and directing the current for a few seconds inversely, and then as long directly. But these testing, "searching" applications should never be continued, in any epileptic case, longer than a few minutes at any one *seance*.

The *rule* is, then, first, to find out if there is any *external* cause acting persistently or periodically upon the nerve centres; next, to intercept or prevent this irritation from reaching the centres, or rather to *destroy* this cause, whatever it may be, for according to the more recent researches, this is found very frequently to exist. When the spot of *aura epileptica* is discovered in the sentient nerves of the skin, treat it just as if a severe neuralgic point, i. e., by a *direct*, continuous current. But the source of the aura may be from the ovaries, the stomach, or bowels, or come through the eye, or the mind. If not discoverable, and the patient is robust, then apply the continuous current *down the spine*, and repeat it every other day.

*Tremor.* — Any involuntary trembling of the limbs, head, or body, when it occurs without definite muscular twitchings, is termed *tremor*. It is the main symptom of the singular disorder known as "*shaking palsy*," or *paralysis agitans*, which is believed to be due to some lesion at the tubercula quadrigemina. It must not be confounded with what are called muscular twitchings, although both these affections arise primarily from a deranged and enfeebled innervation, rather than from organic disease. There must be muscular action, however, to present a tremor; but it is characterized by a somewhat rapid and prolonged seesaw, or weaving motions.

It evidently depends upon a weakened state of the nerves and muscles, and still more upon the diminished or deranged controlling power. It is most frequently seen in old age, and during chills and fever. We are also called to see it in the workmen of mercury or lead works, in plumbers, and those who are poisoned by bad liquors, or who are addicted to the long, *moderate*

use of stimulants, or tobacco, or opium; and in some cases from too much strong tea or coffee. When of long standing, it is more evidently connected with organic derangement of the great nerve centres.

*Mercurial tremor* is known by the gradual manner in which it comes on, and from the fact that the trembling, and the incessant *weaving* movements stop as soon as the shaking limb is supported; and by its occurrence in those who work in mercury, or have taken it; by wakefulness and disorder of the digestive organs, and the sponginess of the gums. For this, electrify the muscles through sponge electrodes, so as to exercise them, and then Faradaize the skin over the extensors of the affected limb or part, as also over the whole back, daily, every other day, or twice a week, according to the gravity of the case. Prescribe also something like *formulæ* 13 and 6, or 29 and 31, or 7 and 9, with air, sunshine, and out-door occupation.

*Agitans*, or "tremblings" from the poison of alcoholic drinks, as more frequently seen after delirium tremens, — muscle and limb tremblings from the poison of mercury, opium, lead, or arsenic, — and the tremblings of exhausted muscles, as from protracted monotonous work, or from premature old age, are greatly benefited by bathing all such extremely enfeebled nerves and muscles or limbs with a brisk current of Faradaism. To this end, employ the *team electrodes* by ceaseless (*labile*) movements, and this to be followed by the gentle frictions, strokes, and smoothings of the palms of the hands; then cover with fur or flannel. If this is carefully performed daily, yet not overdone, the restoration is remarkably uniform, speedy and complete.

*Paralysis agitans*, or *shaking palsy*, is, in the early stages at least, but an increased degree of *senile tremor*. It is similar to chorea in some respects, but in others is quite different. There are weakness and *tremor*, rather than spasmodic contraction, or a want of control over muscular motions. Then, as the malady progresses, the propensity to lean forward, or to walk on the fore part of the foot, in a little trotting gait, is very characteristic. This peculiar affection emphatically belongs to advanced life. True, it is sometimes seen in manhood and middle life, but far oftener in persons over fifty or sixty; yet this affection,

usually, has little or no influence to shorten life. It is seen in both sexes, but more frequently in men. But few men approach sixty without showing diminished nervous and muscular vigor. Overwork then done, results in trembling; this repeated can result in true *agitans*. Electricity, with *formula* 5, nourishing food, and a little wine or brandy at dinner, will help such persons, but not always cure.

### *Ague — (Chills and Fever.)*

*Ague*, with its complications and aggravations, presents a peculiar variety of compound affections, which, indeed, may be termed "*the great endemic*" of the southern, middle, and western portions of these United States. It may be met with, in occasional cases, in every part of this country, and in every country. This is often modified so as to constitute one of the great classes of diseases which are known to us only by their group of symptoms, but by which it is fairly identified. I must, therefore, first of all, describe the phenomena of *ague*.

Ague is, in type, intermitting or paroxysmal; and remitting, or exacerbating; and hence is denominated *periodical*. In this respect it resembles several other affections that belong essentially to the nervous system. A person exposed to the so-called "*malaria*" (in employing this term I do not commit myself to any theory of its origin or nature) may present indisputable evidences of its pernicious influence, without showing any regular attack of chills or fever. Its depressing or poisoning influence may be inferred by the loss of appetite, nausea, general indisposition, or diarrhœa, neuralgia, palpitation, debility, emaciation, or anæmia; while other persons, similarly exposed, may retain their usual good health. But in persons of all these classes, periodical chills, or chills and fever, or a bilious fever of some deeper grade, and perhaps accompanied with congestion of brain, cerebellum, spinal cord, lungs, &c., which give peculiar character to the given case, are liable to set in, and are often suddenly developed without premonition; brought on simply by any depressing cause, mental or physical, as anxiety, taking cold, fatigue, an accident occurring, or even exposure to the

night air, or derangement of the stomach: either is sufficient to initiate the attack.

An ague fit is composed of *one*, two, or three distinct stages, but more usually of *three*, according to the gravity of the case; and they are severally named the *cold*, the *hot*, and the *sweating* stage. Thus a certain series of symptoms occurs, and then the patient reverts again to more or less seeming health. This alternation usually happens, or *returns*, if the disease is left to itself, a great many times. A person who is on the verge of a paroxysm of ague feels a sensation of debility and distress about the epigastrium; he becomes weak, languid, and unequal to bodily or mental exertion. The blood deserts the superficial capillaries; he begins to sigh, to yawn, to stretch himself, and soon is chilly, and says he feels cold chills along down his back, or there is a very aching, disagreeable feeling through the loins and pelvic bones. He now grows pale, his features shrink, and his skin is dry and rough, showing the *horrida cutis* — *cutis anserina* or "*goose-flesh.*"

Presently, the slight and fleeting sensations of cold, first felt creeping along the back, become more decided and more general; the patient feels *very cold*, and begins to tremble and shiver all over, and his teeth chatter, as one who is exposed to intense cold, and is overcome by it. His hair bristles slightly, his knees knock together; his lips, ears, fingers, and nails turn blue, and are actually cold; he is eager to be in a warm bed, or by a great fire. In bad cases the breath is cold. He complains of pains in his head, back, and loins as being terrible; at the same time all the secretions are diminished, for though he often tries to make water, he voids but little, and it is pale; his tongue is dry, and coated white or pale yellow, and his bowels are confined. In a simple ague, "*the back and bones aching*" during *rigors* predominates, while in very grave cases the rigors are less violent, but there is extreme restlessness and distress, and then the system is prostrated almost beyond the capability to react, and a prolonged cold stage is the result, lasting sometimes for four, six, or ten hours.

Ague, in all its forms, simple, complex, and grave, is certainly attended with nervous debility. *The ganglionic system of nerves*

*suffers most.* Is this the reason the liver, the spleen, lungs, brain, or some other central organs, are liable to enlargement? How often we find this the state in post mortem examinations! In the more grave cases the skin is not only shrivelled and pale during the ague, but it is often of a dusky, purplish hue. In such cases the skin may be dry, but more usually it is damp, or even wet, with exhalation, which sometimes is glutinous; and the skin may be deficient in sensibility to such extent that external irritants, such as sinapisms, blisters, and even electro-magnetism, produce no impression. But this condition of skin is mostly confined to the limbs, nose, cheeks, and ears, and where the cold stage continues for many hours. Dr. Manson, of North Carolina, in his report to the American Medical Association, in 1860, says, "The cold stage of grave remitting fevers, congestive fevers, malarial pneumonia, &c., rarely continues beyond eight or ten hours. Then the reaction comes on, sometimes violently feverish, while in other cases there is scarcely any reaction; and this stage continues from ten to twenty-four hours; and this is succeeded by a stage of congestion of some vital organ, which, in turn, yields to a reaction more or less distinct, or is fatal; the disease having a tendency to terminate on the third, fifth, and seventh days mortally, or subsiding into the mild form of ague, or intermitting fever."

The duration of an ague *shake* is from twenty minutes to an hour, more or less. Then, after this state of general distress has lasted for a time, it is succeeded by another state of suffering, of quite an opposite kind. But I have seen very many cases of ague where the chills, the "*shakes*," were the whole of the disease, so far as series of symptoms are concerned, excepting perhaps vomiting and thirst. Indeed, I have witnessed, within two hundred miles or so of the Cape, at Jefferson Barracks, in Southern Missouri, and in Southern Illinois, south of the American bottom, hundreds of cases of marked ague; i. e., where the paroxysm is incomplete, or there is no distinct stage at all. These cases are termed by the people "*dumb ague.*"

But when an ague case has a feverish nature, the *hot* stage immediately succeeds the chill. The cold shivering begins to

alternate with flushes of heat, and by degrees the rigors and coldness cease entirely, the skin becomes smooth and warm, the collapsed features resume their ordinary bulk and appearance. The reaction goes beyond the healthy line, the face becomes red and turgid, the general surface hot and dry; the temples throb, the pulse is full, strong, and rapid; and there is now another set of head sensations. The urine is still scanty, but now high colored; the breathing is oppressed, and the patient is restless and uncomfortable generally.

After a long while, to him, another change comes over him; a moisture appears on the forehead, face, and neck, and presently a copious and universal sweat breaks forth, with great relief to the feelings of the patient. The nausea and thirst cease, the pains and restlessness calm down, the tongue becomes moist, the urine copious but turbid, the pulse becomes calm and more natural, the pains depart, and gradually the sweating also terminates; and thus terminates a series of symptoms and suffering, which leaves the patient as well, or nearly as well, as before. But all this will regularly return, and return.

The accession of the chill, fever, and sweat is called the *exacerbation* or *paroxysm*. The period that elapses between the termination of one paroxysm and the commencement of the next is called the *intermission*. When the intermissions are perfect and complete, the patient resumes the appearance and sensations of previous health, and the disorder is called *ague*, or an *intermitting fever;* but when the case shows imperfect intermissions, the patient remaining unwell and feverish, though uncomfortable in a less degree than during the paroxysm, then he is said to have a *remitting fever*.

Ague, if left to itself, as we have said, *will recur*, usually, at very regular periods, and for a certain length of time. When the paroxysm occurs at the same hour *every day*, the patient is said to have *quotidian* ague. When it comes on at the same hour *every other day*, it is called a *tertian* ague. If the paroxysm absents itself for *two whole days*, and then recurs, the complaint is called a *quartan* ague. Thus, in the quotidian type, the interval is twenty-four hours, in the tertian forty-

eight, and in the quartan seventy-two hours. These three are the principal types of ague. Moreover, each of these types of ague is peculiar to itself; and one singularity is, that the quotidian ague usually comes on in the *morning*, that of the tertian at *noon*, and that of the quartan in the *afternoon*. Such is not invariably the case, but is usually so.

How long will an ague run? i. e., how many times will it recur, and for how long a time? If left to run its course, no one can tell. Ague, in some cases, consists of a very few paroxysms only; three or four, or of two, or even of one fit; or they may recur over a space of several weeks, or months, or during many years.

*Congestion of the brain* sometimes complicates a case. The patient complains of pain in the frontal region, of an acute, throbbing character; the intellect is confused and wandering, and he is disposed to sleep, the drowsiness gradually increasing into coma; the pulse is frequent and small. Finally, as fever begins to take the place of the cold stage, he becomes again restless, and complains of cephalic pain, and nausea, or vomits, but gradually regains his faculties, and he soon is comfortable and hopeful. But this is a deceitful calm. The cold stage comes round again with increased violence, and increased cerebral symptoms, and increased prostration of vital powers. By proper medical assistance, the second cold stage assumes a milder character, and the case gradually subsides into a mild remittent, or intermittent. When the disease, however, continues unabated, the third paroxysm usually proves fatal, though in some cases death does not take place until some time after.

*Congestion of cerebellum, pons Varolii, and medulla oblongata* complicates a case with another set of characteristic symptoms; there is complaint of fixed pain in the occipital region, and of internal heat and oppression; is very restless, and shows great difficulty of breathing, and want of air. The dyspnœa is evidently owing to impeded innervation, from a congested condition of the vessels of the cerebellum. The patient will often get out of bed, but his gait is staggering and unsteady, and he is likely to fall; but he will of himself rise again; showing, as Dr. Man-

son contends, that it is not simply from debility that he cannot stand up, but from a want of control over his muscular movements. With the hot stage comes relief of pain in back of head; but there is nausea or vomiting, and the stomach responds to the action of medicine readily. The cold stage again comes about, i. e., where there is no medical aid, and the second paroxysm is prone to prove fatal.

*Spinal congestion* complicates other cases; but here, during the cold stage, the symptoms are of a milder character than in the preceding severe cases. The spinal pain is usually in the dorsal and lumbar regions.

*Treatment of Mild Remittent.* — If the pulse is full, or hard and resisting, a cathartic, or emeto-cathartic, and local bleeding will be invaluable; particularly if there is intense cerebral or spinal pain. Leeches to the temples, or cups to the back of the neck. If nausea or vomiting, or other symptoms of gastric irritation, faradaic currents to epigastrium, and over the bowels by faradaization, will be followed by great relief. To this add a simple enema of salt and molasses, a table-spoonful of the former to a teacup half full of the latter, added to a pint of hot water, and given at once quite warm. From the conjoined action of electricity and the injection, the bowels will respond, and render the patient very much more comfortable and safe.

In the *treatment* of bilious intermittent and remittent fevers, we should rely principally upon emeto-cathartics, mercurial cathartics, quinine, diaphoretics, and electricity *applied to the epigastrium*, abdomen, and back, from the nucha to the coccyx, by faradaizing with team electrodes, as the case may require. In many cases, where we suspect a foul stomach, or torpid liver, and excess of bile, a good dose of ipecacuanha with capsicum, say thirty grains of the former to five grains of the latter, more or less, and given at once in a table-spoonful of sirup, which should be followed, in five or ten minutes, with copious draughts of water. After the emesis subsides, this should be followed with a cathartic, given in the course of two or three hours, or as soon as the medicine can be retained. While vomiting, and longer, the patient should keep in bed as much as possible, to encourage general perspiration. Not unfrequently, when first

called to such a case, even before prescribing the emetic, or emeto-cathartic, we have at once ordered a warm wash bath in a warm room, to be used with plenty of soap, and towel freely applied; and immediately the patient is to be placed in a clean hard bed, — no feather bed, — in a room well ventilated.

For children, if a case of much severity, where the first and sometimes the second paroxysm of fever may be moderate, but the third paroxysm is apt to be ushered in with a convulsion, which seems to answer to the cold stage in the adult, and which is so alarming and truly dangerous an occurrence, it is prudent to bring the system very rapidly under the influence of quinine, and cut short the disease by the abortive process. The ordinary head and lumbar pains which invariably accompany remitting fever, do not contra-indicate the free use of quinine; on the contrary, these symptoms are most speedily relieved by its use, with or without dover's powder, enemata, or bilious cathartic, given concurrently. But where the symptoms are less urgent, it is better to postpone the quinine.

In a report read before the American Medical Association in 1860, by Dr. James H. Dickson, on the prevailing epidemics in North Carolina, we find the following synopsis of treatment for mild remittents, which we quote condensed: —

*In the exacerbation*, "cold drinks, the effervescing draughts, and iced lemonade may be freely allowed. At bed-time, say at nine or ten o'clock, it is almost our invariable rule to administer a cathartic dose of calomel and rhubarb of ten or twelve grains each. At some period before or after midnight, the fever will be found more or less to *decline*. We prefer this period for commencing the abortive means; because our experience convinces us that quinine, the principal remedy, is then better borne, and produces its salutary effects in a more decided and complete manner than at any other time in the twenty-four hours.

"We therefore, at this period, usually administer from ten to twenty grains of quinine at a single dose, in pills, or diffused in a wine-glass full of water. We regulate the dose by the degree of fever present. If it is intense, we administer the larger quantity; if quite moderate, the less will answer. Under the com-

bined action of the mercurial and quinine, free evacuation of the bowels will usually occur, but rarely excessive. Three or four hours are now suffered to elapse, during which the topical bleeding is repeated, if the local symptoms do not yield.

"The condition of the patient will now be found generally much improved. The cerebro-spinal pain is either removed or mitigated; the pulse less frequent, and more soft; the skin relaxed and moist, and the gastric irritation subdued. We therefore repeat the quinine, in diminished doses of five or six grains, every three or four hours, until the period of chill has passed, generally exhibiting from twenty-five to forty grains before that time. In cases attended with much gastric irritation, or diarrhœa, the addition of a full dose of opium — say one and a half to two grains — to ten or twelve of the sub-muriate hydrarg. at bed-time, instead of the rhubarb, forms an excellent combination, which will enable the stomach to retain the quinine afterwards administered, with more certainty.

"Under this plan remittent fever, as it appears usually in the United States, is certainly and safely cured. We have, in this manner, arrested the disease in many hundred cases, each in one night. Owing, however, to the peculiar liability of the affection to relapse, or terminate in protracted intermittent, we usually continue the treatment. We think it advisable to prescribe an alterative of calomel, or mass hydrarg., for two or three successive nights, followed by eight or ten grains of quinine, or twenty drops of oil of turpentine, in divided doses, on the succeeding mornings. In cases attended with coma, delirium, or convulsions, during the exacerbation, topical bleeding will be freely required, and the application of cold. We have, however, been more gratified with the effects of the cold *douche*, in these complications, than with any other remedy. In such cases a full dose of calomel should be given, followed by stimulating enemata. Such is the abortive plan of treatment for ordinary remittent fever occurring as a primary form."

In protracted cases a different practice will be found necessary; as quinine is not well borne, and the antiphlogistic remedies detailed are *contra*-indicated. Minute doses of calomel combined with opium will usually be found of great service, given for a

while with the oil of turpentine, which latter may almost be regarded as a specific in this variety or stage of the disease. It is more suitable in this condition than quinine, as it is better tolerated; and while it possesses febrifuge properties very similar to the alkaloid, it also exerts a happy influence over the gastric and intestinal irritation so commonly present. It may be given in doses of ten to twenty drops, in emulsion, repeated every three or four hours until the symptoms yield. It should be persisted in until the patient is fairly under its influence, unless the effects it occasionally produces, viz., hæmaturia, strangury, or its peculiar intoxication, supervene — when of course it should be discontinued. The muriated tinct. ferri would be likely here to give the finishing touch of cure.

In the *cold stage* of a severe remittent, it is all-important to use external means, as warm clothing; and even hot applications to the limb are to be persevered in assiduously until reaction. Moreover, the active use of electro-magnetism should be applied, during this time, by faradaizing the back and bowels. This, too, must be smart, and persevered in until relief. To aid and insure the reaction, dissolve ten grains of quinine in two or three ounces of hot water, and add a drop or two of tincture of capsicum, and ten drops of spirits of camphor; or if there is looseness of bowels, in the place of capsicum, add thirty drops of laudanum, and give this mixture by injection, to be retained, and repeated every half hour, or less often, until reaction appears. If the patient shows by nervous manifestations spinal congestion, doses of turpentine (see *formula* No. 18) alone, or combined with dover's powder, and repeated every hour or two, are an excellent remedy. By perseverance in these simple means, grave cases usually do well, and speedily recover.

When the reaction does take place, it is apt to be very violent. The fever is intense; therefore the treatment must be more vigorous. Ten or fifteen grains of calomel alone, or, if gastric irritation, combined with five or ten grains of dover's powder, are to be followed in two or three hours by a full dose, say fifteen or twenty grains of quinine; and quinine is to be repeated in five to ten-grain doses every three or four hours, until thirty or forty

grains are taken. The time of giving the doses should be so regulated, if possible, that the last dose may be taken only two or three hours before the return of the expected paroxysm. Says Dr. Manson, "I have never seen a chill, or cold stage, recur, if forty grains of quinine have been taken and retained." When the paroxysm is fairly broken up, the patient may generally be considered out of danger; yet it is a prudential measure to keep the patient on a gentle alterative course, with small doses of quinine occasionally given for several days or even for weeks after.

But what of the electric remedy? In all degrees and forms of *ague*, and malarial affections, the application of faradaic electricity to the stomach, abdomen, and over the vital organs, is almost invariably of the greatest service. I speak advisedly. Place the patient upon his back, well covered and warm, excepting the region of the *stomach, spleen, and liver*. Then, with one sponge electrode in each hand, the physician applies the negative first at the umbilicus, then with the other bathes over these organs lively, with increasing strength of current, — a very strong current, — for five, ten, or fifteen minutes.

*Treatment.* — First, the *place:* the patient, we presume, is in bed, in a room where the air is *dry* and warm, (not sitting up before the blaze of the fire, nor where a draught of wind is allowed to blow upon any portion of his body or limbs.) Second, the *time:* just a little before the hour and minute for the invasion of the cold stage, *shake*, or rigors, is the time to work. Prepare the patient comfortably; wet the sponge electrodes in *very warm water*, or salt water, and see that the battery or machine works well; then commence *before* the *horripilatio* of yawning, stretching, sighing, "cold chills down the back," goose-flesh, and collapse of the features, *get the start*, (as in Faradaic tooth-extracting,) and maintain it, first, by a current from the nape of the neck to the regions of the liver, stomach, and bowels; next up and down the back; and then using *team-electrodes* to Faradaize the surface. When the chill is broken, repeat a daily *seance*, but at different hours, to fortify the invigoration.

## CHAPTER IX

### ELECTRICITY IN MIDWIFERY AND UTERINE AFFECTIONS.

*The Modus Operandi.* — But first, what of the general principles? Before the faradaic, or galvanic currents of electricity could be any way satisfactorily employed, or resorted to in emergency in midwifery practice, two fundamental points had to be decided, viz.: —

*First.* What are the effects of the different kinds of electric currents, when applied by certain given methods, on the contractile structure and functions of the uterus; and if any effect, can it be any thing like uniformly obtained, so as to be relied upon as a therapeutic?

*Second.* What form of electricity, and what is the best method or methods for applying it to the patient *under different circumstances*, so as to obtain the greatest benefit without producing much pain, or any other inconvenience; and in what cases should it not be used? If it is efficient, is it always safe?

In a word, we can say, that it is now fairly proved and settled that electricity does exercise a controlling influence over the uterine fibres; and that most uniformly and powerfully when the primary, or the *faradaic* current *extra* or secondary, is very strong, and is maintained continuously from a few minutes to a few hours at a time, (according to the case,) in a down-running direction. In practice this is best done by planting the positive large moist sponge electrode on the *nucha*, (back of the neck,) or, as I more usually prefer, over the upper dorsal spine, between the shoulders; while the negative electrode sponge is being glided over the waist, ribs, breasts, and about the abdomen; or is held on the flank just above the groin on one side, and then on the other; or over the vulva, or *perinæum*.

It is well, sometimes, and even necessary, in some cases of great atony, or other urgency, and where other methods fail, to

introduce the vaginal glass electrode with silver tip, so as to place it on, into, or about the cervix uteri; and then, in some cases, frequently, as often as every half minute, reverse the current direction, for both direct and reflex effect. Not so should we proceed, however, if there have been long diseased action and inflammation, or pains of spasm, rheumatism, or neuralgia. (See *Rules*, on page 466.) Generally, the immediate or local application of electricity to the uterus, as by both electrodes in the vagina, or one there and the other in the rectum, is less effective, whatever the current or the method of applying it. With the positive sponge electrode placed high on the spine, or on the dorsal region, or at the pit of the stomach, while the negative is on the lower region of the abdomen, and slowly glided from side to side, or to the vulva or perinæum, or down the inner side of the thighs, is the better plan usually. But, sometimes, if the wire brush, as the negative, is painted lively over the abdomen, or the vagina electrode is moved about the cervix uteri, it may induce contractions not otherwise aroused.

The *uterus* has for its more immediate motor-centre the plexus of the sympathetic, as distributed upon the largest blood-vessel in the body, the aorta. But the real starting-point, or *true motor-centre* of the uterus, (which, upon being excited by electricity, produces contractions and movements in the uterus,) as seen in vivisections, is situated in the cerebellum and medulla oblongata. From thence, downwards, contractions of the uterus can be excited by the application of electric currents (as also corroborated by similar recent trials in vivisections by Dr. Frankenhauser) to any and every part of the spinal cord, whether applied to its outer surface or to its internal structure; the excitation is in fact transmitted by the fibres connecting the sections of the cord with the sympathetic and the *nervi uterini*.

Irritation of the spinal cord, between the third and fourth lumbar vertebræ, only occasions contractions, while the connecting fibres with the sympathetic remain uninjured; whereas, after separation of the *ganglion mesentericum* and the aortic plexus, no contractions of the uterus can thus be produced, but only contractions of the bladder and rectum. And yet upon galvanic irritation of the aortic plexus alone, active uterine con-

tractions always occur. It is now known, therefore, that the intermediate, or coördinating centre of the uterine contractions, is the inferior mesenteric ganglion.

Movements of the uterus, as I have witnessed in vivisections of various animals, are most readily induced by faradaic electricity applied to the afferent or efferent nerve branches of the mesenteric ganglion; for if the electrode is applied directly to the ganglion itself, there is seen less effect. Hence we find that the *plexus aorticus*, when thus excited, induces contraction of the whole body of the uterus, especially if the *nervi spermatici* are also stimulated. If the application of electricity is made to only one side or the other of this plexus, the corresponding side of the uterus is made to contract first, and then this contraction subsequently spreads over the whole organ.

Thus it results that the sympathetic nerve, distributed upon the walls of the aorta, is found to be a direct and immediate motor centre for the uterus, whilst its ganglia form, collectively, the intermediate centre for motor excitation; while, at the same time, it is equally true that smart electric excitations of the nerves issuing directly from the sacrum and proceeding to the uterus, *induce no excitation or contraction;* but, on the contrary, actually check movements in the uterus. Hence we know that the sacral nerves are to be regarded as channels for inhibitory action upon the uterus, (*reflex?*) that is, to restrain, repress, or *regulate* its actions. But it is equally true, that, in order to produce this result through these nerves, a very strong electric current must be passed from a positive electrode at the sacrum, while the negative is over the uterus, or in it, or else well up in the rectum or vagina.

Guided by these general principles, the author has employed this agent, by given methods, under varying circumstances, sometimes with ergot, but oftener without it, and uniformly with very remarkable success. Some of these cases were critical. In one case, a sudden and frightful hemorrhage had occurred, in a primiparia, in the last months of gestation, where the placenta was attached to the cervix uteri, and it was desirable not only to stop the further loss of blood, but to bring on labor as expeditiously as possible.

In this case I applied the ordinary faradaic current of full strength, in a continuous down-running direction, first from back of neck, and then from upper dorsal region, to the umbilicus; then lower on the bowels for a while; and finally placing the sponge electrode over the vulva at rest for a half hour. During this time the flow of blood was stanched. The negative was only glided on to the perinæum, and the labor now set in regularly, and advanced so naturally, that this young wife was delivered that same night of a living child. Both mother and child did well. In this case I maintained a continuous down-running current *for four successive hours*, with only good results. But let us first investigate more minutely the reasons as well as the results.

The uterus may be contracted by a given application of electricity, whether gravid or not. Clinical experience, of late, has fairly demonstrated that by the employment of the Faradaic or Galvanic currents, the uterus in the living woman contracts *in toto*. Recently, Dr. McKenzie, of England, exposed to view, as is well known, the gravid uterus of a pregnant bitch, and then, by means of the electro-magnetic currents applied in a certain way, he perceived, after a given time, a slow vermicular-like movement of the muscular coats of the uterus, which resulted in general contractions. This was also perceptible to the touch of the fingers. The phenomenon was far more marked when the *positive* pole was applied to the spine, while the *negative* pole was being applied to the cervix uteri, than when both electrodes were directed to the substance of the uterus. He ascertained that an electric current directed perpendicularly, i. e., in a direction through the uterus from the fundus to the cervix, promotes powerful and general uterine contractions; whereas currents passed transversely through the organ excite but partial contractions, and those limited to the fibres embraced between the electrodes. *Dr. McKenzie insists that it is necessary to apply the positive pole to the nape of the neck, while the negative is at the cervix uteri, if we wish to act surely and energetically through the great sympathetic, upon the contractile fibre-cells of the involuntary muscular substance of the uterus, in any great emergency.*

Herder, Stein, and Kilian in Germany, Radford and Barnes in

England, and Bertholon in France, have employed, and still recommend the employment of, electricity by induction, as aid to midwifery practice; especially so in cases of tedious labor; in some forms of *placenta prævia;* and for *atonic* hemorrhage from the uterus *post partum;* also for originating uterine contractions where necessary to induce premature labor. Dr. Cleveland, of England, we notice, advises to apply the sponge electrodes over the surface of the abdomen, only changing their site from time to time.

After all, Professor Simpson, of Edinburgh, is rather of the opinion that electricity in midwifery practice is all but useless; for, as he thinks, whenever uterine contractions have been *apparently* excited by any electric current, the phenomenon was rather a coincidence; or else it resulted from the impression that is made upon the mind of the patient; or else is produced by the mechanical irritation of the uterus, or of the surface of the abdomen, by manipulating with the electrodes. At least, such were his conclusions a few years since. Now, if these electrodes were a kind of "Perkins's Tractors," as some one has before suggested, we might be necessitated to find a mere occasional *coincidence*, or some show of reason for an occasional effect; but, when we recollect that these electrodes are no inert things, but actually convey a power that controls all living muscular fibres, both of voluntary as well as involuntary muscles, and contractile tissues also, (more slowly, it is true, but as surely,) and when, from a given strength and direction of current, employed under given circumstances, on different portions of the body or limbs, we uniformly find certain results, I can see no force in these reasons, further than an opinion. Certainly, it is contrary to the whole drift of evidence in my own experience in midwifery practice. There are very many women who become exhausted before the labor is terminated. There is a state of temporary inertia sometimes, *that must be aroused sufficiently for the emergency.* Electricity is better for this than ergot, according to my own experience. There are others, also, where ergot of itself will not suffice, but resort must be had to instruments. Here, too, I have found electro-magnetism better than lever, hook, or forceps.

It appears to me to be as safe and effective as it is painless, if correctly and patiently applied. If there is plethora, or any active inflammatory condition, it will not succeed. If it is very long applied, say for hours together, it will *increase* the atony, rather than relieve it. In extreme *inertia*, it will fail because there is nothing to arouse. It is here contra-indicated. Indeed, it is a *rule* to be scrupulously observed, the more feeble or exhausted is the patient, or the more protracted the inertia has been, the more careful we must be not to prolong the application very far — certainly not a moment beyond the attained contraction or suspension of hemorrhage. But in some atonic and hemorrhagic states, not attended with plethora or inflammation, and not otherwise contra-indicated, we can *rely* upon electricity, when skilfully employed, to be of most signal service in saving life-blood, and even life itself. (See Rule 10, p. 466.)

Dr. Swan, and also Dr. Robert Remak of Berlin, in 1839, expressed the then prevailing opinion that the human heart and uterus possessed very few and very small nerves. But Dr. Robert Lee has demonstrated in the 41st and 42d volumes of the Philosophical Transactions, that there are nerves, which he illustrated by three engravings, showing, on these organs, numerous great ganglia and plexuses of nerves. He says "these enlarge with the coats, blood vessels, and absorbents during pregnancy, and which return after parturition to their original condition, as before conception. Recent dissections which I have made of the ganglia and nerves of the virgin and of the gravid uterus have enabled me not merely to confirm the accuracy of these descriptions and delineations, but to discover the still more important anatomical and physiological truth, that there are ganglia situated *in the muscular substance of the uterus* and plexuses of nerves, which accompany all the arteries, veins, and absorbents, distributed throughout its walls. It is demonstrated by these dissections that there are not only great ganglia at the neck and on the body of the uterus, but ganglia between the strata of the muscular fibres, and that the whole muscular and vascular structures of the uterus are pervaded with ganglia and nerves. If the dissections which have been made of the ganglia and nerves of the virgin uterus be compared with those of the gravid uterus,

it will be seen that the nervous structures of the uterus enlarge during pregnancy upwards of seventy times."

*The Uterine Nerves.* — The power we possess over the uterus by this means is very great indeed, and the modes by which we can exert it are very various. We may excite the nerves of the external surface of the uterus, the nerves of the internal surface, or the nerves of the *os uteri*, respectively. When, for example, we produce uterine contractions by irritating the uterus through the abdominal surface, we act on the first series of nerves; when we inject cold water into the uterine cavity, or introduce an electrode, we act on the second; and when we irritate the *os uteri* by digitation, we act on the third. These measures, as well as this knowledge, are of great importance in our attempts to arouse the uterus itself to action. Now, in all these varied actions, the excitor nerves, the spinal centre, and the motor nerves are concerned. The uterus does not contract simply and singly from any inherent power belonging to the organ itself. Its actions from these sources of excitation depend mainly on its connection with the spinal marrow. Doubtless there are other forms of action mixed up with those which are purely *reflex*, and to these I shall presently revert; but what I would contend for is, that much of the uterine action consequent upon irritation of the uterus itself is as strictly *reflex* — as much produced through the medium of incident and motor nerves, and the spinal centre — as are the uterine actions caused by irritation of the mammary or rectal nerves. This is what I cannot too much insist upon.

If we here follow the original views of Dr. W. T. Smith, we see that the plexuses of the abdomen, like the external plexuses, are simply mechanical adaptations for mixing nervous fibres and communications from different sources, and applying them to the uterine nerves, it becomes a possibility, and I may say a *probability*, that the uterine nerves are more variously derived than any other nerves of the human body. They may be derived from different points of the great nervous tract between the origin of the pneumogastric nerve in the *medulla oblongata*, and the origin of the sacral nerves in the *cauda equina*. There is, moreover, no actual impediment to the approach of nervous

fibres to the uterus from the medulla oblongata through the medium of the *vagus*, or from the cervical portion of the spinal marrow by the *phrenic*, or from the thoracic by the splanchnic nerves, and from the dorsal by the compound lumbar branches of the *sympathetic* and the sacral nerves, which latter come directly from the spinal cord. Dr. Smith gives the following physiological proofs of the existence of a large supply of nerves to the uterus. He says, —

"There is no doubt that the uterus is susceptible of pain; this is one proof of a nervous connection between the uterus and the brain as the organ of sensation. No one doubts that an emotion of the mind may excite the uterus to powerful contractions. This is another proof of nervous connection between the brain and uterus. No one denies that, during pregnancy, the uterus affects sympathetically the most distant organs, producing the changes in the mammæ, and the gastric disturbances, which are so universal. These facts are explicable by the existence of nervous communications between the uterus on the one hand, and the stomach and mammæ on the other. There is no other route than that afforded by the nervous system. No one denies, either, that after parturition, the breast or the stomach may excite the uterus to action; these facts further prove a reciprocal influence *from* the stomach and breasts *to* the uterus. Such facts are, in their sphere, as convincing as though the eye could see a great concourse of nerves running between these organs. A physiological fact is worth quite as much as an anatomical fibre. These communications can only take place through the medium of nerves, and whether there be one channel or many, whether the chief place be given to the spinal fibrillæ of the sympathetic, or to the proper nerves of the spinal cord, the necessity for uterine nerves is equally inexorable. There *must* be nerves, and there must be nerves *sufficient* for the functions to be performed. Anatomical facts can never give the lie to the facts of physiology."

There are three modes of exciting contraction of the uterus. Reflex contractions may be excited, says Dr. W. T. Smith, —

1. By stimuli applied to the mammary nerves.
2. By stimuli through the medium of the pneumogastric

nerves, as when food, hot or cold drinks, ergot or emetics, are taken.

3. By stimuli directed to the upper spine, and to the abdominal or intercostal nerves. For this purpose, electricity is the first and best.

The cutaneous nerves of the abdominal parietes are excitors of the uterus in an extraordinary degree. The sudden impression of cold or heat, or both in quick alternate successions, upon the abdominal surface, will almost always excite the most energetic contraction of the uterus, when affected with *inertia*, and from which, perhaps, hemorrhage is taking place. We may contract the relaxed and diffuse uterus to a firm ball, by *douching* the abdomen with cold water from a height, or by splashing a towel, taken out of cold water, upon the naked abdomen, or by suddenly placing the hand, just taken out of iced water, upon the umbilicus. If the surface of the abdomen should be cold, the sudden impression of heat produces similar contraction. In all these instances it is the *reflex* actions from the extremities of the cutaneous nerves of the abdomen which are affected by the stimuli. The result takes places too instantly to permit the belief that any sensation of cold or heat passes through the abdominal parietes to the uterus itself. The extremities of the cutaneous nerves of the abdomen are, in fact, almost as distant from the uterus as the superior intercostal nerves which supply the mammary glands. As to the true mode of action from irritation of the mammary and pneumogastric, and the abdominal intercostal nerves, there can be no doubt left whatever. These nerves are too remote from the uterus, in their peripheral extremities, to admit of any other explanation save that of the *reflex* function.

But what I wish to insist upon is this — that all the actions I have been describing are *reflex* in their nature. Physiology repudiates the idea of uterine contractions excited by means of continuity or contiguity of the organs excited, with the organs which contract. The peripheries of the nerves of the bladder, rectum, vulva, and vagina receive the impression through the incident nerves and the spinal centre, while the motor nerves of the

uterus, distributed to its muscular structure, are all concerned in the muscular contraction which ensues. Though the organs excited are near the uterus which contracts, the route of the nervous action is precisely the same as it was in the case when the stimuli were applied to the mammary or the pneumogastric nerve. I make these observations because I still see the obsolete notion, which so long perplexed physiology, of referring all such actions to the sympathetic nerve, and to the mere anatomical distribution of nerves to neighboring organs from the same source, cited by some authorities as sufficient to account for all such motor phenomena as those which take place between the different pelvic organs respectively. They look only at the nerves interlacing and communicating with each other, and their minds do not reach to the necessity of considering the spinal centre as the organ which connects the roots of motor and excitor nerves, and *provides the power*, as well as a way-station "*ganglion*," for prompt nerve-telegraphing.

Moreover, Dr. Smith speaks of "the different modes of exciting uterine action by stimulating the muscular irritability of the organ," as distinguished from the excitement of muscular action through the nerves. He mentions three methods by which this is performed — the application of cold, mechanical irritation with the hand, and the use of galvanism. With regard to the latter, he says, "We find that in patients perfectly paraplegic, with entire loss of reflex uterine power, yet the uterus has been excited to contractions sufficient to expel the fœtus by means of electro-magnetism. Dr. Radford, of Manchester, applied this power to the arrest of uterine hemorrhage. One pole of a galvanic trough being placed *within* the os uteri, and the other applied over and above the fundus, it has been found that on making and breaking the galvanic circle every half minute, powerful uterine contractions occur. It is said that the uterus can be made to contract by this agency when it will obey no other stimulus whatever, and I have little doubt that this is correct. It accords with all we know of the influence of electricity upon the muscular fibre. The contraction of the uterus from galvanism is probably the most simple mode in which we can act directly upon the irritability of the

muscular fibre, and the contained ramifying nerve fibrils, without necessarily complicating it with reflex action, (if this is so in fact.) The reflex actions excited by passing galvanic currents through muscles alone, we know, are very slight, if they occur at all. This is proved by a great number of experiments. There is, however, one important disturbing agency in the application of galvanic currents, which must be taken into account. The application of this remedy, and the painful sensations it excites, disturb the emotions considerably. In some such cases, the emotional excitement increases the influence of galvanism; in others, it weakens or suspends its sensible action altogether. This is probably one of the reasons why, in some cases, galvanism produces little or no contractile effects."

In a discussion on this subject, in one of our medical meetings, some time ago, it was objected that the contractions of the uterus were caused by the titillations of the os uteri, alleging that electricity could have little or no effect upon the nerves and muscles of organic life and function. Since that time I have had a case to the point, where the placenta was retained in utero, the cord having parted nearly ten hours before, during which time the most strenuous efforts were made, by titillation of the os uteri, as also by pressure, and strong manipulation of the parietes over the womb, to cause it to contract and expel; but all in vain.

On arriving, (for it was at Newton Corner,) Dr. Hosmer, the attending physician, informed me that, within the last three hours, she had taken three drachm doses of powdered ergot, and it was an hour since the last dose was given; a firm roller having been placed around her body. There was no definite uterine contraction, only a strange sense of trembling and distress. The patient was immediately turned upon her back, the vagina glass-electrode, with metal tip, was carried into the *os tincæ*, and connected with the positive conductor of a Hall's electro-magnetic machine; at the same time, the sponge positive electrode was applied to the umbilicus, and so moved upward, with full current-power of the machine suddenly let on. Instantly the faradaic current began to run, the abdominal muscles contracted. The sponge on the abdomen was at once moved,

but quite slowly, however, gliding up and down, and from side to side; and every fifteen seconds the direction of the current was *suddenly* changed, by reversing the current-changer of this machine. In less than five minutes there was a strong uterine contraction, which promptly expelled the whole placenta, together with a large quantity of clots. The uterus remained contracted, and the lady did well. A uterine sound, covered with India-rubber tubing, except at an inch or two of its tip, and moistened with soapy water, is easily carried within the body of the uterus.

*Pro Inductione parturiente.* — As regards the *power* and the *safety* of electric currents to this end, when in skilful hands, we are now able to quote the more recently reported experiences of such distinguished names as Drs. Barnes, Cleveland, Radford, Mackenzie, H. R. Storer, Houghton, Frank, Jacobs, Harting, Honiger, Henning, Demsy, Dorrington, and Duchenne. Either the voltaic, the galvanic, or the faradaic current, if strong, and long enough continued, (that is, for one, two, or three hours,) according to the rules herein laid down, has more or less the power *to initiate uterine action de novo*, which I know from experience, as also for aiding defective uterine action in many cases, when not attended with great hyperæmia, nor yet *extreme* anæmia, or prostration — for uterine atony, whether pregnant or not, with hemorrhage or without.

In conclusion, I must say, therefore, that I consider electricity, when appropriately employed, as a parturifacient, far preferable to ergot *in a majority of cases*, when either is indicated; for the reason that the pains so induced are regularly rhythmical and intermittent, just as they occur in natural labor, and hence not likely to injure either the mother or the child. It is perfectly safe, therefore, in all uncomplicated tardiness, to employ electricity either for *initiating*, *inducing*, or *increasing* the parturient contractions of the uterus. Where the hot drinks and stirring about fail, electricity will often succeed; and it is to my mind far more prudent to resort to it than to ergot.

*Asphyxia in New-born Infants.* — For many years electricity has been resorted to for the purpose of exciting respiration, and frequently with success. Dr. Scholzer has long and strongly

advocated its adaptation. Sommering first advised to this end, placing the electrodes so as to excite the phrenic nerves; for this causes a contraction of the diaphragm, and hence a deep and true inspiration. But it was Dr. Ziemssem, in 1857, who first demonstrated, by experiment, the very spot where the phrenic nerve is most superficial, and easily touched by the current. This nerve, it is known, lies on the outer border of the sterno-mastoid muscle. The author has found it most practical and easy to place a large sponge electrode, positive, on the side of the neck, and so glide it along on the shoulder, and over the cervical and brachial plexuses, working it lively and in waves, while the other sponge electrode is over the middle and lower portions of the respiratory muscles, and often reverse the current. Thus electricity at suitable times is useful for these obstructions.

### *Amenorrhœa.*

The methodical use of electricity is of inestimable value as an *emmenagogue* in young women, where the menstrual function has not appeared, or where it is not fully established in consequence of a want of action through the vaso-motory nerves of the ovaries and uterus. No less important aid is rendered by Faradaic currents for those young females who are threatened with phthisis, by determination of blood to the lungs, or where there is a vicarious hemorrhage or discharge. For these, I can testify that the Faradaic *seance* comes to the aid of the practitioner, in a professional sense, "as a very friend in time of need." I would not be understood to claim for it unfailing success, even where there are no morbid changes. Yet I can say that it is so frequently, and indeed quite uniformly, successful, — coming to the rescue when the ordinary and extraordinary means have long proved not quite sufficient, — that no physician can now afford to be without this excellent therapeutic at his command.

A curious case is mentioned in the New York Journal of Medicine, 1844, by Dr. Le Conté, of the south. He states that a woman, more than seventy years of age, residing on a

plantation in the State of Georgia, who had ceased her menses for more than twenty years, on being struck by lightning, her menses were completely reëstablished, and continued with the utmost regularity for more than a year after the accident. During the same time her breasts were enlarged much as they were in early life.

The best "methods" of treating amenorrhœa by electricity is a question, since different great authorities advocate somewhat different plans. M. Becquerel admonishes us, in the first place, not to employ electricity at all, for this or any other disease in the female, "*during the catamenial flow*," as it is very liable to put a stop to it. I would call particular attention to this remark of Becquerel; so much do I regard its importance, that it has been a very *rule* with me in all electro-therapeutic applications.

The point I am able to confirm here, from experience, is that electricity, when properly administered, in suitable cases, is one of our most reliable emmenagogues, in all cases where amenorrhœa or dysmenorrhœa has its origin in a deficiency or disturbance of the nervous element. In almost all of these cases, which depend upon an organic cause, the use of electricity is *contra*-indicated. If there is inflammation, congestion, or ulceration, or contracted cervix, it of course will fail to do good. Nor does it always calm the nervous pains, dull or acute, seated in the uterus, from branches of the lumbo-sacral nerves, which appear to become exaggerated at the menstrual period, and which may *simulate* true dysmenorrhœa.

A true dysmenorrhœa, I take it, is a ganglionic, interpelvic neuralgia; that is, a disturbance in the vaso-motor innervation of the womb. These are the cases for electricity. As a neuro-tonic, electricity supplies or arouses, in the nervous system, the energy and harmony it has lost, and the cure is often speedy and complete. But when the menstrual disorder is depending upon the derangement of a *vital* element, as where there is evident plethora, or, on the other hand, an extreme anæmic state, electricity alone should not be used. But let the chlorosis be partially removed, or the plethora be reduced, and it becomes an heroic, a magic remedy indeed. So also when the menstrual

disorder is depending upon a diathesis that is in a state of exaltation, as scrofula, or some skin disease; for here we must first use iodine, or arsenic, or sulphur, with quinine, or iron, or cod-liver oil, to correct the morbid diathesis, to some degree at least, and then the electricity comes to our aid for reëstablishing the torpid or lost menstrual function, and we may confidently rely upon it. (See *methods*, p. 466.)

*Treatment.* — For *amenorrhœa* we must proceed much as we would for atony, and for inducing labor pains. The positive sponge may first be planted on the back of the neck, while with the negative, the region about the breasts, over the solar plexus, the right and left ovary, the inner sides of the thighs to the knees, are to be gone over for fifteen or twenty minutes. Then, with both electrodes on the abdomen, move them so as to strongly exercise the rectus, oblique, and other muscles, and awake peristaltic action, and uterine action, through reflex nerve action. All this presupposes the proper condition of the female system, at the time, for the function to be so reëstablished.

But for many cases of *dismenorrhœa* we must proceed very differently. For treatment, — that is, with a view to the mode of treatment, — I place these patients in two classes. The one, larger class, I treat just as if neuralgic, by placing the negative sponge at the coccyx, and with the positive bathing over the solar plexus, the ovaries, and the abdomen; or, with the negative planted on the inner side of the knee, work the positive as before, and so on down to its fellow at the knee, and then cease. The other, smaller class, are to be treated as the cases of amenorrhœa, because depending, evidently, on the same pathological state.

For atonic *menorrhagia*, and for all *uterine inertia*, the methods and rules, as explained on page 466, and in the fore part of this chapter, are simply to be carried out expeditiously, in connection with other suitable means.

Another condition for success in using electricity for these cases is, in choosing the right time for its administration and repetition, which should correspond to a menstrual period or nisus. For instance, I saw a young lady of eighteen, who had menstruated for three years, but on going to a new boarding-school, or from taking a sudden cold during the period, the discharge was

abruptly suppressed, and gave rise to amenorrhœa, which had lasted for some months, and might have lasted for an indefinite time. She came home to the city under my care. The abdomen was decidedly enlarged, and she appeared dropsical. There was no albumen in the urine, as I ascertained. At periods, answering to her menstrual, she had suffered considerable pain and distress. Watching for this, and in the mean time giving her iron and quinine, with a minute quantity of strychnia, (one fiftieth of a grain of the latter per day,) when the painful period approached electro-magnetism was applied twice, and the discharge was restored. At the approach of the next period, on the very first day of the admonitory pain, it was repeated; and again the flow appeared in the following night. The cure was complete.

*Case of Miss B.* — Twenty-two; was of a lymphatic temperament; had suffered for six months from amenorrhœa, complicated with extreme chlorosis. Dr. E. H. Clark had for some time been giving her chalybeates, and for the two last periods had given her apiol for three days each, but without success. He sent her to me. Her skin was dingy white and waxy; her feet, hands, and face were too plump, showing effusion, and her gums were blanched. She had commenced menstruating at fourteen, but was tardy and scanty, the discharge often being white, changing to reddish color, but invariably attended with such severe uterine pains that she was usually sick abed. I applied electricity, and repeated it at three successive periods, in conjunction with the apiol, iron, &c. The *severe* pains left her, the discharge became more prompt, more colored, and more abundant. Two years have shown it was a cure.

*Leucorrhœa.* — In the treatment of this, undue prominence must not be given either to local or constitutional treatment. In some cases, either alone can cure; but in most cases, both general and local treatment is required for decided and permanent relief. There are a variety of causes and conditions that keep up a leucorrhœa, but it is only where there is a local or general state of weakness, that electricity can cure, or aid in curing. The great mass of cases of leucorrhœa occurs in persons of feeble habit, or those whose constitutions have been

injured by disorders of menstruation, or abortions, frequent child-bearing, or prolonged lactation; if no ulceration or active local inflammation, these are the cases that electricity can aid us in curing, and diminish the tendency to relapse.

If leucorrhœa occurs in plethoric habits, operate with the positive sponge electrode on the sacrum, or under the coccyx, and give iron, combined with saline aperients, and alteratives. But for the greater portion of cases, operate with the positive high on the spine, or placed stationary at the pit of the stomach; while with the negative sponge the whole abdomen is bathed over, as well as the thighs; following this, in some unimpressible cases, with faradaizing these same surfaces, through the wire brush, brushing lively over them; and also where the vagina is pale and relaxed, first insert the glass electrode, and then attach the conductor, and let on the current by degrees, and move the electrode about every minute, higher or lower, for ten or fifteen minutes. Never attempt to introduce or remove this electrode while the current is running.

Astringent vaginal injections, used so as to wash the entire surface of the pocket, are cleanly, and help very much, not only to dry up the discharge, but to astringe the neighboring tissues, and so coöperate with the electric current to give and maintain tone and adjustment to all the delinquent parts. In those of a strumous habit, the iodide of iron, as *Dr. Blancard's pills*, is of the greatest value. In cases attended with gastric irritability, give rather the ammonia citrate, or the citrate of iron; in cases attended with relaxation of the system generally, give the sulphate of iron, with quinine, or nux vomica, and the sesquichloride of iron. Some of these constitutions require steel medicine every other month in the year, to keep them on the track, and up to par. Others will poorly bear any appreciable quantity of iron preparations; and these I advise off, annually, to the various chalybeate springs of our country, according to their several needs.

In plethoric women of gouty, or a rheumatic habit, and suffering from leucorrhœa, local depletion by leeches, salines, alkalies, and low diet, with air and exercise, and no indulgences, are neces-

sary for a recovery. In the menorrhagic cases, only the astringent preparations of iron are admissible. In the chlorotic females, in whom torpor of the rectum, ovaries, and uterus exists together, and where the leucorrhœa is owing to a relaxation of the glandular system, is *aloes*, or any aloetic preparation, any way admissible. In all other cases, as also in menorrhagia, aloes, in any shape, increases leucorrhœa, and is distinctly contra-indicated.

In Guy's Hospital, electricity is considered not only admissible for treating these cases, but moreover *as the only true and reliable emmenagogue we possess.* Yet it is by no means to be used here exclusively, any more than in any other case. When visiting that hospital, I observed that they mostly employed static electricity, giving the patient a dozen or so of shocks at each *seance*, from a quart Leyden jar, fully charged, and directed through the pelvic region *from* the lumbar or sacral spine *to* the *symphasis pubis*. By the reports of that hospital for the past fifteen years, it appears that this has been the *chief reliance* when the condition of the organism was right for its use, or had been prepared by iron and tonics, and that out of twenty-four cases of amenorrhœa twenty of them were thus cured. Dr. Duchenne in France has also been very successful with this class of patients, using invariably strong electro-magnetic currents locally applied, i. e., to the uterine organs.

It is, I think, now a well-authenticated fact, that the application of a brisk electro-magnetic current to almost any part of the body or limbs, if about the *period* of her menstrua, *is liable* to induce a flow of the menses in any female that is at the time in a physiological state *capable* of that function. In treating these affections, it is always advisable to make such trials as will most possibly spare the moral sensibilities of our youthful patient. To this end, direct that a large moist sponge electrode be applied by herself or attendant to the groin, or *perinæum*, (which is better,) or to the upper inner side of the thigh, while the other electrode is carried by the operator's hand to the lumbar and sacral regions of the back. This last electrode should be the positive, and at high speed, while the

tip of the conductor may be repeatedly touched, and for a few seconds retained, to the binding screw of the machine. Thus we are enabled to *shock* the patient, to increase the circulation in the uterine region, and to arouse the functions there to life. Generally speaking, I prefer maintaining one electrode somewhere up or down the spine, even on the *nucha* or under the *coccyx;* let the other be where you please — over the pubis, vulva, or perinæum, or in the vagina, or above the groin on either side. Never remove the electrodes until the *seance* is through, but suddenly break and make the contact at the binding screw, also reversing the current direction now and then, (provided she is not a nervous person.) By this means we find we can shock nearly as well as by a Leyden jar, and the patient can bear it daily. I have said that electro-magnetism is our great ultimate emmenagogue; also that it will *as surely stop* the menses if applied to the female *during the flow.* But I must add, that in cases where the flow is tardy, pale, or but partial, then, too, by this agent can it be increased in quantity and quality, and become prompt.

*Case of Chlorosis.* — Miss E., nineteen years of age, graduate of one of our highest and most fashionable female seminaries, but with decidedly enfeebled health. Her general appearance is that of a very beautiful girl, *minus* color and vivacity; for she is remarkably well developed and plump, but fair and white as marble, lips and gums blanched, tongue pale, wrinkled, and indented, and her eyes languid. She came under the care of Dr. Edward H. Clarke, who, after finding that tonics, nutriment, and chalybeates, together with out-door and horse exercise, and the cessation of study, did not stay the anæmic and declining tendencies in this girl, therefore sent her to me to receive such *electrical treatment* as I might judge to be advantageous in her case. There was distinct systolic bellows sound of the heart; urine was about twelve ounces in every twelve hours, which was rich with albumen, epithelial casts, and crystals of the triple phosphates of ammonia and magnesia, and there was long-standing amenorrhœa. She was greatly troubled at times with intercostal neuralgia; had a hacking cough which besieged her severely on retiring to bed, but there was no expectoration; her lower limbs

from ankle to knee not any way anasarcous, but were peculiarly plump, fair, and polished, as if beautiful statuary.

The electric treatment of this case was commenced, therefore, with the view of first increasing the capillary circulation, and the endosmodic and exosmodic process. To this end I employed first a smart current of Faradaism, and then that of Galvanism, at each *seance*, which was repeated daily, using large metallic ball electrodes covered with wet wash-leather, with which the surface was gradually gone over, holding the balls as *team electrodes*, (with only one or two fingers between them ;) and then by polar alternations, labile movements, and sudden current reversing, I caused the muscle fibres to contract, and this with redness and heat wherever the electrodes were applied and swept along, which was done over the whole back at one seance, for example, then over the lower limbs at the next, &c. At the same time this patient remained under the mutual watch and care of Professor Clarke, who simply advised a diminution of medicine, but a continuance of the same regimen as to food, exercise, and rest. It would be interesting to detail the progress of this critical case; suffice it to say, however, that after the first four weeks her improvement became manifest to all; there was some evident return of flesh color; she had more appetite, and her menses had returned; she was stronger; said she did not feel "so tired;" was quicker in thought, speech, and action; and in one month more she began to play on the piano, at which she was a great proficient. But I do not feel confident of her safety; besides, Dr. Clarke tells me, that her sister has for years had more or less hysterical paraplegia, and I fear there is wanting a real foundation for any truly substantial health, although on auscultation the bellows sound is gone from the heart, and the cooing sound from the carotids; showing that the due balance of the blood circulation is reëstablished, the torpor is overcome, and the capillaries are fairly awakened to duty.

*Prolapsus Uteri.* — In the Edinburgh Medical Journal for 1856 we find the following editorial on the *Displacements of the Womb:* "It is our impression, that there is not a sufficient regard to the recognizance of the uterus as a 'floating body,' or rather as a body whose mechanical conditions of equilibrium

make its support more nearly analogous to that than to any other mode of support. The most considerable *solid support* to the uterus is the vagina. These two conditions lead to an easy understanding of many phenomena of the minor motions of the uterus, called misplacement, or displacement. The failure of the vaginal support through relaxation (amounting sometimes to a sort of paralysis) of the vaginal tube, and often accompanied by a similar condition of the rectum, leads to the most complete displacements of the womb while healthy *in itself*, and leads also to all the ordinary symptoms of uterine ailment in the most aggravated forms, which are curable *only on conditions of curing the vagina.*

"Again, enlargement, and consequently increased weight, of any part of the uterus, leads to a falling or sinking of it. Enlargement of the cervix leads to depression of the organ. Enlargement of the body, causing top-heaviness, leads to retroversion or anteversion, or flexion. It is nearly certain that the ligaments of the uterus have almost no function as ligaments, but quite the reverse; and that in those cases of displacement where symptoms of dragging are ascribed to them, there is, *in fact*, no such dragging at all. The uterus has free motions afforded to it by these ligaments, which are not to be put on the stretch by any ordinary misplacement. It must also be remembered in regard to uterine flexions, that the organ is sometimes so softened as not to be capable of bearing its own weight — a circumstance sometimes connected with leucorrhœa, and symptoms of pain." (See Rule 10, p. 466.)

Here, evidently, are a class of ills peculiar to females, that, in a rational sense, ought to be greatly amenable to the power of electro-therapeutics, — and so they are. If I should report the contents of my case-book under this head, it alone would make a volume of no small interest.

*Retroversion, Obliquity, and partial Prolapse of the unimpregnated Uterus.* — In the first place it is very important to be able to diagnose the varieties of prolapsus and other misplacements; for only certain classes of cases can be benefited by our specialty. For instance, in one class of cases, occurring during the child-

bearing period, and commonly depending on more or less active inflammation or congestion, with enlargement of the neck of the uterus, electricity can be of no service. If, however, the organ remains mal-positioned after the reduction of the œdema, engorgement, or inflammation, that in the first place produced and accompanied it, then we have a case where electricity can be made available. In some more atonic cases, indeed, it can be used earlier, and so aiding even in the latter part of the reduction of the irritation and plethora of the parts, also increasing and diffusing the circulation, and *giving tone and muscular support to the enfeebled and relaxed abdominal parietes, and loins, and inter-pelvic parts, also through reflexed effects of faradaization.* In these cases the vagina needs to be restored to its natural contractile properties.

In some instances it is really necessary to replace the tilted or fallen womb from its *out-of-place*, from time to time, in cases of atony or œdema, by means of the *digitus medius*, or uterine sound; and in some cases to introduce pessary, sponge tent, or suppository, for temporary support, and thus to give as reasonable aid or opportunity for the electric treatment to equally tone each part naturally, and to produce peristaltic motions, as well as nerve and muscle response and adjustments, during the seance, as possible.

The uterus and vagina, rectum and bladder being all relieved, and thus well adjusted, electricity can now be applied by proper methods adapted to the given case, with very great confidence of its power to aid materially in the restoration to health. Iron, tonics, and local treatment, where they cannot succeed by themselves, may in this have invaluable aid which the medical attendant cannot honorably do without. For uterine derangements, and retroflexion especially, produces some of the most complicated, obscure, aggravated, and exaggerated cases of chronic distress, both mental and physical, that woman's nature is capable of enduring. Man's nature could not endure it, nor could it beget such suffering. The correct treatment, and every aid to give it success, is, therefore, of the greatest importance.

*Case of Mrs. A.*—Aged thirty-eight; of a genteel family; mother of five children; has of late been consumptive inclined, and suf-

fered from menorrhagia, dilated and patulous os, and partial prolapsus. After long suffering, and getting no better, she was sent here by her physician, "*to try the effects of a shock.*" She was naturally a delicate lady; and now being very feeble, it was judicious to make the *seance* as easy and short as possible. Placing her in a reclining posture on the lounge, she rested while I worked. Finding the abdominal muscles very flabby, cold, and tender, nothing was done at this time but to electrify the abdomen, loins, and thighs, and prescribe *formula* 12. Three sittings more were spent in this manner, on every other day, when it was apparent to all, that a marked improvement was begun.

At the fourth seance the positive sponge electrode was placed inside her dress on the cervical spine, and then with the silver-tipped glass vaginal electrode carefully inserted within the still existing widely dilated os, the faradaic current was let on, and carried to the inner fundus of the uterus. By moving this negative electrode about a little, for fifteen minutes or so, she soon began to feel its warming and contracting effect, which was also somewhat painful, but slightly so. At subsequent sittings I noticed that she gave almost no signs of pain, although I think she did feel it, because she was so sensible of the benefit of it, and anxious to have it continued, that she would not acknowledge that it hurt her.

On the ninth seance I had to be content with carrying the electrode into the upper vagina, and then finishing by electrifying the abdomen, loins, and thighs; for the uterus was well contracted, in very good position, and the vagina seemed more firm, fixed, and compact. Not even the insulated uterine sound could now be inserted within the os, after ten minutes' application of the current to the parietes of the abdomen. Her monthly was postponed the first time for near two weeks, and then came painless and prudent. After that it was right and regular. She came under my care again, in two months after, for a dozen more sittings; and now, three years since, she has a babe six months old, and is in her very best health.

*Undeveloped uterus* is now and then found to be the cause of tardy or partial appearance of the menses in young ladies; and it may be found in married ladies the cause of barrenness. The

galvanic (*intra-uterine*) *stem-and-egg pessary*, first employed by Dr. Simpson, of Edinburgh, is the most direct, safe, and efficient remedy. But I have found the want of development in the uterus often associated with, or the result of, spinal injury or disease. Where this is the case, of course further remedies must be instituted.

### *Breast-Milk.*

The lacteal secretion is a veritable nervo-chemical phenomenon; yet the good effects of electricity on the mammary gland, in case there is very deficient secretion, suppressed or poor secretion of milk, and in other abnormal states of the milk-giving breast, (except the inflammatory,) show it to be not so much a chemical as a physiological action through the nerves and vessels that determine this secretion.

*As a lactescent*, either the primary, extra, or secondary current of electricity may be employed for this purpose, applied daily, or twice a day. Use only large, fine, and moist sponge electrodes. Apply the positive on the back of the neck at first, and with the negative, weak, gently bathe the breasts over for five minutes each; then taking one in each hand, apply them on opposite sides of the breast, and increase the current so as to pass it through them in various directions; then finish by placing the positive in the axilla for the last five minutes. The current should not be painful.

As electricity has the power to *promote*, and *re-establish* the flow of breast milk in women, so will the external use of belladonna, together with the internal use of iodide of potassium, *arrest* the secretion of milk. The iodide should be given in three to five grain doses every four hours, and perhaps a dover's powder at bed-time; while a soft and pliable belladonna extract plaster should be applied so as to completely cover the breasts. A saline should be given in the mornings sufficient to keep the bowels free. In twenty-four to forty-eight hours the tumefied breasts will begin to subside.

# CHAPTER X.

## NERVOUS AFFECTIONS OF THORAX AND ABDOMEN.

### *Heart Derangements and Diseases.*

*Pericarditis* may occasionally be attended with mental aberration, slight and transient; and it may appear early or late in this disease. But other nervous symptoms, occurring in more frequent cases of heart disease, are apt to be developed, which are highly important in themselves; and all the more because they mask the real heart disease, and mislead the unwary and the inexperienced. These symptoms now and then *simulate* chorea, tetanus, epilepsy, coma, dementia, mania, and even inflammation of the tunics of the brain, where there is no disease; while the true disease of the heart may be overlooked until a *post mortem* reveals the fact.

*The delirium* incident to pericarditis is peculiar; "the patient is found lying in a species of coma vigil — the eyes open and fixed in one direction, not replying to questions, and incapable of being roused; this state followed by maniacal excitement, the patient shouting and laboring under the fear of harm, with occasional ebullitions of hilarity. A fixed delusion of having committed some crime appears to be a distinguishing feature."* The relation or pathological connection between the grave nervous symptoms and pericarditis is believed to be functional; although many have attempted to explain the matter through disordered circulation, an altered state of the blood, or nervous irritation transmitted through the phrenic and pneumogastric nerves. Sleep is often impaired by pain in the region of the heart, or by dyspnœa. Anxiety and mental depression, belong to the history of these persons. Albuminaria coexists in quite a

* Flint on Diseases of the Heart, p. 310.

large proportion of the cases, and when ascertained, shows a morbid condition of the kidneys *antecedent* to the pericarditis, and upon which the development of the latter depends; when this is the origin or complication, the case is most likely to prove speedily fatal.

In treating acute rheumatism, (as well as when such nervous symptoms arise as I have just delineated, and that without other clear cause to account for them,) it is important to be on the watch for the earliest evidence of a friction sound of the heart, indicating pericarditis or endocarditis, with further evidence of inflammation; because it is of the greatest consequence to know the fact, if it occurs, so as to treat this formidable affection promptly and successfully; to be late, is to fail. If Bright's disease, or organic disease of the heart, complicate the case, it is equally unfortunate. Pericarditis occurring with rheumatism rarely proves immediately fatal; but if from renal disease, and with marked nervous disorders, a fatal result occurs almost invariably.

*The treatment*, specifically and generally, during the stage of effusion, may be greatly aided, often, by means of the revulsive, reflex, and stimulating effects of repeated faradaization over the region of the vital organs. This is indicated in proportion to the urgency of those symptoms which show that the heart is weakened by paralysis and hampered by compression. As regards the success of treatment early in rheumatic effusions, we are confident; but so far, for instance, as atrophy or fatty degeneration of structure has taken place, the lesion must be considered incurable. Still, the heart, like the other important organs of the body, may sustain a certain amount of damage, while there still remain sufficient healthy tissue and functional power for life and health, even though that which is actually lost in structure may not be recovered; yet the deficiency may be made up by increasing the development, and vigorous action, of the normal tissue which remains.

From habitual weakness of the heart's action for a given time we may find atrophy, fatty degeneration, or *softening*. Functional weakness of the heart, causing either of these, will be likely to be associated with marked general debility of the mus-

cular system. Here nutritious and easily digested food, with brandy or other alcoholic stimulants, is also indicated, as well as electricity. The patient's mere consciousness of undue violence, or of irregularity of the heart's action, exclusive of other evidence, is not significant of organic disease. On the contrary, where the patient complains of this as the prominent symptom, the presumption is, that organic disease does not exist; it is more likely to be a nervous functional derangement. It is surprising how insensible the patient usually is to the excessive force and great irregularity of action, who has true organic disease of the heart. The pulse may or may not be of assistance in the diagnosis; it usually is; but we must rely more on the immediate physical signs and the history of the patient's case.

*Functional Disorders of the Heart.* — By this term we mean simply disturbed action, without inflammatory or organic affection. These latter are often attended with functional disorder; but functional disorder can, and most frequently does, exist without those diseases. This *disorder* — the fluctuations in the actions of the heart — may be very various. The organ is morbidly excitable; the action is simply increased unduly by transient causes, such as mental emotions, or muscular exercise, indigestion of food, or stimulants, &c. It commonly occurs only at times. In severe cases the patient is painfully conscious of a violent beating of the heart, or of a tumultuous and extremely irregular action. A feeling of impending death is experienced, and absolute repose is not only prudent, but actually necessary; the terror of the patient, in fact, often increases the disorder. Derangement of the nervous system is, doubtless, the more immediate cause of functional disorders of the heart.

Various morbid agencies, protracted or repeated, *induce* a state of nervous derangement, of which, now and then, a functional disorder of the heart is a prominent feature and a distressing manifestation. "Venereal excesses and the solitary vice are frequent causes. In the endeavor to trace this and other effects of derangement of the nervous system to their source, the practitioner should not omit inquiries as to sexual indulgence in the married; for there are persons who appear to

think that any amount of legitimate indulgence is innocent; and, when questioned, will confess to having practised one or more acts of coition daily for a series of years. The excessive or even moderate use of tobacco is another cause. This is a very frequent cause. Strong tea, in some persons, occasions severe paroxysms of palpitations." * Dr. Stokes has cited several striking illustrations. "Strong coffee induces this effect in certain conditions of the system, or in consequence of a peculiarity of constitution." † Excessive mental exercise and protracted vigilance belong to this category; and, more than all, long continued anxiety or distress of mind, with dyspepsia.

Symptoms of functional disorder of the heart differ materially, according to the various conditions of the patients. In the plethoric, this affection is accompanied by strong pulse, flushed face, pain in the head, and determination of blood to the brain. In the anæmic, the attending phenomena indicate feebleness of the circulation; for the lips are pallid, the pulse is small and quick, while the feet and hands are cold. In the hysterical and hypochondriacal, it is pretty sure to be a prominent feature. As incidental to dyspepsia, it is better or worse with the state of the stomach. In fact, simple functional disorder of the heart is more a *symptom* of the existing morbid condition that induces it, and is not entitled, strictly, to be considered an affection of the heart; nor is it scarcely ever liable to run into organic disease of the cardiac apparatus.

*Faradaize* over the solar plexus and the region of the heart, and electrify all the thoracic muscles. Reassure the patient, away with indulgences, correct all errors of mind or organs. Treat the case on general principles, rationally, with more regard to the state and habit of the nervous system, than the habit of the heart.

*Narcotism of the Heart by Tobacco.* — This is a more frequent occurrence than has been generally recognized. The partial effect is very insidious; and the smoker or chewer, though conscious enough of the cause as well as of the effect, rarely is

* Flint on Diseases of the Heart, p. 406.

† *Vide* Stokes on Diseases of the Heart and Aorta, p. 533.

willing to let it be known, if he can possibly avoid it. But sometimes it is more complete, and then simulates some serious affection. One day last summer we were called in haste to see a young gentleman in Franklin Street, who, it was feared, had fallen dead, or was dying, from heart disease. He was a member of the firm, twenty-seven years of age; had a robust frame; had been in his usual good health. He had suddenly dropped at his desk, without any apparent premonition, and while looking over his books and smoking a cigar.

At once we suspected the cause, and therefore ordered several active stimulants, internal and external. He was almost pulseless, breathless, pale, cold, and bathed in perspiration; but this, through electrical and otherwise radical treatment, soon brought him to his senses. He gradually revived so as to go up town to his house; but, as we afterwards learned, he did not readily or entirely recover. Some weeks after, he was sent to me by his family physician for electric treatment; which, together with the muriated tincture of iron, restored him to his business capability; but the irregular pulse and nervous prostration did not yield entirely for several months more.

How frequently are physicians called to witness such cases, more or less severe or complicated! Numerous chronic affections of the vital organs, we know from extended experience in these cases, have their origin in the habitual though "*moderate*" use of tobacco, producing at times a faintness at the pit of the stomach, a weak or an irregular or intermitting pulse, pain in the sides, &c. These symptoms, in young manhood, show how great a damage to prime health, and to natural vital stamina, is the habitual practice of *smoking* or *chewing*, though moderate, in very many of our young men.

In England, in all Europe, it is a great evil, but here in the United States *it is alarmingly so*. We cannot undertake to say here how large a proportion of our young men are *reduced* in the scale of *nerve* stamina, and chances for resisting accidental attacks of disease, or for receiving prompt benefit from administered medicines. But medical men, of all men, are "duty bound" to set a good example, and to have an opinion that is clear and decided,

backed up by scientific knowledge, as well as practical experience, which should be *preached* as well as practised.

*Asthma.* — More than one half of all sudden and repeated attacks of asthma can be cut short by a full dose of ipecacuanha, *if promptly given*, so as to insure vomiting within a few minutes after the first symptoms of dyspnœa. This medicine should act before great pulmonary congestion has occurred, and then the bronchial spasm yields. Dr. Reamy, of Ohio, and Dr. Salter, advise this course, not only to save the agony of an attack, but to break up the habit — *to cure*.

*Asthma* is *cured*, in some persons, by the internal use of nitrate of potassa. There is no article in the materia medica that is more effectual in subduing chronic bronchial inflammation than the nitrate of potassa. When asthma is complicated with asthenic dyspepsia, — and very many of the cases appear to be so, — we advise an ounce of the nitrate (*formula* 24) to be dissolved in a pint of boiled soft water, and of this a table-spoonful to be taken three times a day, — that is, after each meal, — and continued for several weeks or months. This, in our hands, has permanently cured many cases. (For electric treatment, see pp. 469, 867.)

Dr. Mackenzie, of Dublin, who has had a very great experience in the use of electricity in treating throat affections, warmly recommends this remedy, also, in the early stages of *clergymen's sore throat*, before the perverted state of the nerves of that region has led to follicular deposit. The positive large sponge electrode should be planted on the back of the neck; while, with the negative large moist sponge, the whole throat and thorax region are well bathed over with lively currents of electricity for some five, ten, or fifteen minutes at a time. Many a weak and morbid throat might thus be surely cured if early and perseveringly attended to, and aided by such other rational means as the given case might require.

### *Consumption.*

The first stage of tubercular phthisis is generally stated to be that in which the *physical signs* indicate a deposit in the lungs. But, able men in this speciality say, we must evidently go farther

back; there is unmistakable and undeniable evidence by earlier symptoms, than there are stethescopic signs — long before the able and most skilful observer can detect the sound which indicates the least shade, or degree, of solidification of the lungs, — *there is an antecedent state* of disordered health, acting as the causative agent, that originates the predisposition or tendency to the deposit of tubercle in the tissues, and elaborates or prepares the material in the system from which only tubercle is formed. *To this very point I would entreat an earnest and careful attention.* Here is the very "point of departure." It is not only the key to the very meaning of the name of this disease, but it is the only truly, i. e., uniformly, hopeful period for treatment.

The actual first set of symptoms of tubercular disease consists simply in the "*wasting of flesh, if this is attended with a lower scale of health and strength.*" Now, this loss of muscle plumpness, as well as juices and fat, is first noticed, according to several good authorities, in three principal places: the first region of flesh *consuming* is the face; second, the hands; third, over the sacral bones. The sacral region, where it first gives out, is lame and sore, and looks poor. The hands look poor and "scrawny," the muscles of the arms and legs are soft and flabby. If the face shows it first, the eyes stare; the brow, temples, and scalp look lean; the muscular tissues of all the limbs soon waste, and the *pectoral muscles*, as also all the chest muscles, waste away, and then the breathing is already become imperfect and weak. This *diminished respiration* is soon attended with cough; then there are pains about the thorax. The patient next is sensible of something wrong, and is conscious of a sense of general debility. The fact is, nutrition is lost; the vital powers are flagging, for the wasting of the organism, in spite of eating, is more rapid than the repair. Then comes a stage of spirit depression; not the *cause* of consumption, but caused by the already deficient vitality, and all the more helping on the catastrophe; for it is a law of our being, that where nerve structure is not itself nourished, it, too, will fail in its work, just as surely as muscle fibre fails of power from the same cause. *With diminished nervous power we all know how the "emotions"*

*begin to master the former intellectual vigor*, and there is no natural resistance made to any accidental debilitating attack, because of an *absent vital energy*. If appetite flags, it is from the absence of the demands of the general vital element in the body and brain; while the *capacity* for digestion still remains unimpaired. This, however, is not always understood, but it is usually blamed, and hence incorrectly treated. Now, I wish to be distinctly understood to say, to every intelligent practitioner, *that all this may occur*, and in thousands of cases does occur, *and yet may be cured in almost every instance*.

In these more *early marks* of an insidious disease, whose fatal end, though not so speedy, is yet even more inexorable than small pox itself, — in this *very early*, and yet, perhaps, full late enough stage of what may as yet be termed "*no disease*," where there is perhaps merely unusual pallor of the countenance, and of the general surface, as also of the mucous membrane of the lips, mouth, and fauces, with perchance here and there some already injected patches in the pharynx, and, at the same time, there are notably *diminished* chest movements, (for the muscles of the thorax are probably already relaxed, if not wasted, though there is but little or no alarm,) the patient most usually being conscious of only a sense of weakness, and a dryness in the air passages which induces a cough, and this is referred to the fauces, pharynx, and upper part of the larynx alone, being most annoying in the early morning, or on changes of weather, or of temperature — this is the stage, and these are the cases, I say, that I have so often met with, which, after having resisted the sedatives, nauseants, and expectorants of orthodox prescriptions, *yield* to the methodical application of Galvanism or Faradaism, directed more especially to the upper part of the spine, *and to the enfeebled chest muscles*. This may be daily or tri-weekly repeated, and that in connection with the very same regimen, and such rational prescriptions as before had not proved quite sufficient to gain the day, being directed to but the internal portion of the malady, while this other portion of it remained unreached, and, perhaps, unheeded. That the general tonic, and perhaps the oil, phosphates, or chalybeate plan of treatment, is likewise needed for these "*not sick*" persons, can scarcely be doubted. This all applies,

however, *to this first stage* of consumption, or, if you please, rather to such marks of a candidate for it; nevertheless, if *here met, and thus managed*, I contend that death, even from uncomplicated pulmonary consumption, occurring, as it does, mostly among the youthful and those in the very prime of life, might become as notably rare, as it is now appallingly frequent. I could show this by detailing numerous and almost uniformly successful cases, but I do not see that it could any way illustrate the *modus operandi*.

*Tuberculosis* designates a certain constitution, or condition of the system, in which there is a natural *tendency* to the deposit or formation of tubercles. We usually observe, in pure cases, a nervous system highly developed. Mind and body active; figure slim; adipose tissue small in quantity; organization generally delicate; skin thin and sensitive; complexion may be light or dark, but clear; in most cases, blush easily; eyes bright, light or dark, pupils large, and eyelashes long; hair silken; face straight or oval, but good-looking and intellectual; ends of long bones small, shaft thin and rigid; limbs straight. Children predisposed to tuberculosis are precocious; cut their teeth, run alone, and talk early. We may anticipate an early deposit of tubercles *while in any state of protracted debility, as a leading pathological agent;* as also fatty degeneration of liver, or kidney. *Debility*, nervous and muscular, or functional, is the most fearful reef to be avoided by such persons.

*Scrofulosis* designates a *tendency*, to this class of diseased manifestation. Here, on the contrary, we find the temperament phlegmatic. Mind and body lethargic; figure heavy; skin thick and opaque, or waxy; complexion dull, pasty-looking; upper lip and alæ of nose thick; nostrils expanded; face plain; lymphatic glands hard, and perceptible to the touch; abdomen full, particularly so while children; ends of long bones rather large; shafts thick and stout. *The leading pathological tendency* in these persons is inflammation of the mucous membrane of a peculiar kind; so-called strumous ophthalmia; inflammation of the tarsi; catarrhal inflammation of the nose, pharynx, bronchi, stomach, and intestines; inflammation and suppuration of the

lymphatic glands from trifling irritation; obstinate or shifting disease of the skin; sometimes caries of bone. For pure, genuine cases of scrofula, Barwell and Jenner advise to give purges of calomel and jalap, or calomel with rhubarb, once a week, for a few times only. Follow with iodide of potassium, quinine, mineral acids, and bitters. Cod-liver oil and iron are here of far less value. But in those forms of *struma* complicating tuberculosis with scrofulosis, which we see occur in fine and delicate persons, purges and mercury, in every form, must be avoided. Cod-liver oil, iron, quinine, combined with minute doses of strychnine, and good nutritious food, are indicated. Electricity, also, is of great service for scrofulosis.

*Debility, with general muscular relaxation* — if with a cool, rough, dry, inactive state of the skin, especially when connected with an interior disease, (but before tubercles are deposited,) such as *torpor*, or asthenic congestion of some one or several internal organs; or where this is the sequel of a previously active internal disease — may be cured, or radically changed for the better, by means of electricity; it being a most powerful nerve and muscle tonic, or revulsive to the surface, &c.; or rather, it can be made so to act, of which the practitioner may often avail himself, as a collateral treatment, in a great variety of diseased conditions in the body. But good judgment, as well as information and skill, is requisite to make it uniformly a success. In very many acute and chronic affections, it is the nervous system which most of all feels the damaging effects of the disease; and it is but reasonable, especially where other medication seems to falter, to direct our remedies chiefly to the nervous system, or to some part of it; and electricity is the most controllable and the most powerful nervine now known to the healing art.

*Nervous Dyspepsia.* — To cure this, the most frequent of all chronic diseases, and sometimes in order to cure other nervous affections arising from it, or *complicated* with this form of dyspepsia, we must learn to recognize it when we see it; we must mark the *nervous* from every other kind of dyspepsia. To this end we must keep in view that the grand object is, by any and every means, to overcome a purely local *stomach hyperæsthesia*,

which also implies nervous *debility in the stomach*. The extremely irritable and feeble state of the organic nerves of the stomach is the reason why liquids *of a high temperature, or large in quantity*, are so injurious in nervous dyspepsia; although hot tea, and even other stimulating drinks, may be resorted to for relief, in the emergency of flatus, spasmodic pain, or other occasional distress in the stomach and bowels of these cases. For the debility in the stomach, and duodenum, sometimes allows them to gradually distend with wind, and then requires a temporary stimulant to arouse them to contract so as to expel it. But to drink hot or any stimulating drinks habitually, daily, is to confirm and perpetuate this dyspepsia. So with *large* quantities of food, or *mixtures* of food at the same meal, or rich or heavy food — so with all sorts of stimulants and irritants to the stomach. So, also, if such persons eat *when very tired*, or *worried*, although it be only proper food, and very moderate, even this will distress them.

The first step, therefore, in the treatment, is negative; that is, to withdraw stimulating and irritating food and drinks, and to see that the nervous system is not overtaxed, nor worried, not yet enfeebled by tobacco, too much bathing, indulgence in bed, or warm rooms. With these precautions, we may with confidence, and in the full expectation of curing, electrify and faradaize over the region of the stomach, solar plexus, duodenum, liver, and the vital organs generally, daily, or every two or three days, according to the urgency of the case. Aid this by all means that will give tone and strength to the whole system. Prescribe something like *formulæ* 5, 10, 24, or 12, or 1 and 7; and pursue this programme rigidly for months. The life, peace, ability, and health-giving result will fully justify the means.

How shall we know nervous dyspepsia from *mucous* dyspepsia, which also so frequently occurs? This is readily discriminated, when purely one or the other; but often they are mixed, or are otherwise complicated, so as to obscure the case. Nervous dyspepsia usually occurs in persons of a nervous temperament; in those of very active temperament; in men and women, and in middle-aged and young persons. It is often the result of *habitual* over-fatigue; a protracted, intense mental condition, as study

or anxiety. "*Bitters*," often and long taken, too much strong tea and coffee, quack medicines, powerful medicines, tobacco, and spirits and beer, are here and there the cause of it.

The tongue is generally red and clean, or else pale, and covered with a whitish, sleek fur and mucus; the gums swollen and red; edges of the eyelids are red; eructations of wind; the skin is subject to small or large boils; the general flesh is reduced, ill nourished, and soft; the pulse is about natural, or too quick and sharp. Such persons show restlessness of mind and body, impatience, irascibility, and are subject to, *here and there*, neuralgia, rheumatism, creeping sensations, numbness, or prickling in the limbs, giddiness, and a sense of being usually *tired*. This leads on to atonic congestion, and to white softening in the brain and cord, and to *gradual* palsy, if the accident of hemiplegia does not appear to forestall this end. Before this result, there usually appear the dyspeptic cough, pains about the thorax, frequent palpitations; and then soon comes tubercular deposit in the lungs, and premature general decay. What, can a simple nervous dyspepsia cause brain softening, spinal softening, palsy, consumption, and decline? Yes, and in thousands of instances every year.

*Mucous dyspepsia* may be looked for, on the contrary, in persons of slow mould, who are bilious and phlegmatic. In these cases, also, the dyspepsia may be the result of a too sedentary habit, or from *excesses* that, on the one hand, exhaust the vital forces, or, on the other, from abuses of the stomach from eating or drinking, and smoking, or both; but most frequently from irregular, improper, or intemperate eating. The food is here apt to rise in the throat, and there is now poor appetite, much thirst, slow bowels, and whitish evacuations. The pulse is full, sluggish, and slow; the tongue is pale, flabby, and trembling, showing indentations, by the pressure of the teeth, about its edges. But, in some of these cases, the tongue is red at its tip and sides, while a heavy brown coat covers its upper surface, more especially back towards its root.

These patients show much flesh, with a dingy, and sometimes dry skin; often *flushes and redness of the face*, but weak and unhealthy fat; and there is a tendency to inactivity, and somno-

lency, irresolution, and low spirits; perhaps dull pain in head, with confusion and indecision. This form of dyspepsia tends more, to lead on to red softening, (*ramollissement*,) apoplexy, and *sudden* palsy — hemiplegia.

Thus, by *nervous* indigestion I designate those symptoms that indicate *debility, with irritability* of the stomach nerves. By the term *mucous* indigestion I designate those symptoms which involve mainly *the lining membrane of the stomach* as the seat of the disease. For the former, for example, I would allow very little fluid, and a small bulk of nutritious food, easy of digestion; as a moderate quantity of bread, meat, and potato, all of excellent quality. For the latter, a farinaceous change of food, from meal to meal, in very moderate quantity, and at regular periods; and almost, if not quite habitually, exclusively farinaceous, for months or a year together, with congress water mornings, every other week; and *formula* 7, 2, 23, or 13. Both of these classes of dyspepsia, as well as the mixed classes, are greatly benefited, and the cure is expedited by the methodic applications of electricity over the region of the stomach, liver, and anterior of thorax and abdomen, at one sitting; and over the whole back and sides, from neck to coccyx, alternating. There is no *one remedy* that pays so well for the trouble and expense as the electric current, when skilfully applied. It comes like a strong and fresh reënforcement to a brave army — it secures the victory.

*Dyspepsia*, of the *asthenic* form, is very often best treated, and cured even, by the internal use of nitrate of potassa, *long continued*. ℞ Nitrate potassa ʒj; aqua bulliens Oj. One tablespoonful to be taken three times a day, that is, *after* each meal. An increased activity in the secretion of urine is generally found to follow, and I suspect the kidneys play no unimportant part in the good brought about. If the dyspepsia is complicated with chronic bronchial inflammation, or asthma, this remedy is admirably adapted, and in a majority of cases will work a complete cure.

*Jaundice* is now and then a complication of a given nervous malady; and the question must arise, for correct treatment, What is the nature of the jaundiced condition? It is of essen-

tial importance to be able to distinguish between the jaundice from *suppression* and that which is caused by *obstruction;* for the treatment necessary for the one, as every physician knows, is wholly inapplicable to the other. Now, it may be laid down as a rule, that when bile acids are found in the *urine*, in any considerable quantity, it may be considered as a certain sign of the existence of some sort of obstruction in the course of the ducts, or else at the termination of the common bile duct. The test proposed first by Dr. George Harley is probably the most ready mode for detecting bile in the urine, and he urges it in all obscure affections involving the liver.

To a little of the suspected urine — say half an ounce of it — add a little white sugar the size of a pea, and when dissolved let it rest. Then pour on gently a little strong sulphuric acid, about half a drachm. This should be done by letting the acid trickle down the side of the glass vessel so as not to mix the two fluids. Now, if the biliary acids be present, there will appear at the line of contact of the two liquids, after standing for a few minutes, *a deep scarlet* or *purple hue*. This result may be relied upon as a sure indication that the jaundice is due to *obstructed* bile ducts. The absence of this phenomenon, or the occurrence of a *brown* instead of the purple tint, is equally indicative of the suppression of bile secretion.

In cases of *melanotic cancer* of the liver, the true nature of the affection may be discovered, during life, sometimes at least by the presence of *melanine* in the patient's urine. This was first shown by Dr. Eiselt, of Prague. Urine containing melanine, although of the normal color when first passed, *gradually becomes of a darker hue*, even as dark as porter, when left for some hours exposed to the air in an open vessel, from the slow oxidation of the pigment. This clearly indicates melanotic cancer in the liver.

In cases of acute or chronic *yellow atrophy* of the liver, it is shown by Dr. Frerichs, in his admirable treatise on diseases of the liver, that two substances, *tyrosine* and *leucine*, are invariably found in the urine of such patients. It is a very fatal form of disease. In the majority of cases, at least, these substances may readily be detected in the concentrated urine by means of the

microscope. The tyrosine appears as needles and little stars; the leucine, as round yellow balls, some of which are spiculated.

In all cases of jaundice, probably, where the bile is retained, there appears in the fæces an abnormal quantity of fat; and hence the fæces are white, and if agitated in warm alcohol, fat may be extracted. The fatty matter does not exist as a neutral fat, but as fatty acids. The passage of fat, in these cases, shows that it is not the pancreas alone that has to do with the digestion of fat food.

*Paralysis of the hepatic plexus* is frequently the sequel of ague and malarious fevers, though sometimes occurring after typhoid fevers, or where there has been no fever at all. The result is jaundice; the skin and urine being deeply tinged, though the flow of bile is ample in the intestines, and the stools show it. In these cases we suppose the liver to be in the same state as the side of the head when the cervical sympathetic is divided. Bile is here secreted in excess; it is a bilious flux. If we electrify the region of the solar plexus and over the liver smartly every day, and follow it at each sitting with faradaization through the wire brush for reflex effect, and give turpentine internally, and repeatedly, if necessary, these cases are speedily curable.

*Obstructed liver*, or chronically affected liver. The symptoms, taken together, show two principal points of disease, viz., the liver and the brain. The former is the point of departure; the latter is manifestly threatened with apoplectic seizure. Only a few days since, I was called to consult with Dr. Wheeler, of Chelsea, for a patient of his, — one of these cases where the apoplexy had already occurred, caused by obstructed liver, — and there were hemiplegia, visible enlargement of liver, tympanitis, and much gastric distress. The disease of the liver, and not the brain lesion, was destroying this otherwise robust man. But if earlier called to these cases, we shall anticipate the palsy. We shall be likely to find an invalid indeed, with limbs shrunk and abdomen enlarged, complaining of pain and fulness in right side. There may or may not be jaundice; for if the liver obstruction be fatty, or abscess, hydatids, or syphilitic, there is

likely to be no yellow hue of the skin or conjunctiva; so, too, as a rule in waxy liver; but if it be congestion or chronic inflammation, scirrhosis, or cancer, there will probably be decided icterus in this malady. The impaired appetite, coated tongue, nausea after eating, short cough, whitish stools, and diarrhœa or looseness of the bowels, alternating with constipation, will go towards the verdict.

But the brain and nervous signs demand our particular attention. The sight is sometimes beset with never-ceasing black spots, with occasional momentary extinction of sight, accompanied with giddiness. There is and has been a dull headache, alternating with feelings of tightness, fulness, or of bursting expansion of the head. The ears are tormented with hissing, humming, or roaring noises. Sleep is prone to steal on in the daytime, and is profound at night; and yet it is disturbed by dreams. The temper is very variable; the will-power is all but gone, and the mind falls into a listless state; only the recurring pain and alarm from giddiness arouses him now and then to make exertion or to desire help. Neuralgic pains occur in different parts of the body and limbs, but especially so in the right shoulder and arm. Dull, heavy, and at times acute pain in the region of the liver. There is usually more or less enlargement of the duodenum, with more or less tenderness on pressure. Pulse generally hard, and slow, and laboring; but at times becoming quick, and simultaneous with palpitations of the heart, as also with irritation of temper.

*Treatment.* — Electrify the region of the liver through sponge electrodes, using a brisk current. One moist sponge — the negative — may be placed over the umbilicus, and held there; while with the positive sponge the liver region and all around the waist are well bathed over by a gentle but steadily-gliding movement for five minutes; then bring the positive sponge to rest on the nape of the neck, and employ the negative with a strong current over the thorax, waist, the region of the duodenum, and over the whole bowels, for five minutes more. Next repeat the first positions for five minutes, which make fifteen minutes in all, and finish the seance. This may be repeated daily, or

every other day. If there is unrelieved pain in the region of the liver, resort to faradaization by the ball or brush electrode for the last three or five minutes of a seance. But in all the manœuvres of the electrodes, in these cases, always observe a *down-running direction* of the current, and there is no kind of fear of provoking the threatened brain attack, but rather the reverse; for this is the most speedy method for warding it off. But if there proves to be active inflammation or malignant disease in the liver, it will soon be manifest by the patient growing worse instead of better.

Put the patient on the lowest farinaceous diet, and give gentle salines, but no mercury. A favorite laxative with me is magnesia and rhubarb, administered every morning. If the patient can exercise, he must do so; if not, he must be exercised by deep-handling with strong hands for a half hour daily. (See p. 453.)

### *Bowels.*

*A case of ilius*, accompanied by fæcal vomiting, is here given as having been successfully treated by electro-magnetism in the following manner: The patient, a man about fifty years of age, was taken ill in the latter part of June last. He had suffered from constipation, and took a dose of Epsom salts for its relief. Next morning the medicine acted moderately, and soon there was extreme pain in the bowels. This rapidly became severe, and soon vomiting and hiccup set in; the bowels were now not acted upon; the whole abdomen was tumefied, hard, and tense, and injections failed to afford any relief. On July 6, ten days after taking the salts, the report is as follows:—

The patient is very restless, throwing his arms about, and frequently changing his position. He is covered by a clammy sweat; his face is haggard, and expressive of great anxiety and suffering; eyes sunken and heavy. Fæcal matters had been ejected by the mouth almost continuously for more than three days. Without some quick relief the patient cannot long survive; and under these circumstances, Dr. Stokes says, he placed the patient on his hands and knees, and there supported him;

while in this position, with his buttocks well raised and his head low, "I passed up *the long elastic tube* with the intention of giving a large enema previous to applying electricity. The tube, after passing through some feculent matter, was readily passed up the intestine to its full length, and the injection was given. On removal of the syringe from the inserted tube, there was no escape of flatus, nor return of the injection. The exhausting syringe was now applied to the tube, but failed to produce any flow from the bowels.

"Without withdrawing this long tube from the bowels, the patient was now placed on his side, and one sponge connected with the negative pole of the faradaic apparatus being applied to the margin of the anus, the other sponge, positive, was applied and passed in a rapid manner, and very strongly, over the whole external surface of the abdominal walls. After a few such applications there was a gush of fluid matter through the tube, which, however, was soon withdrawn, and the negative sponge, with a portion of the metallic handle, was passed up the rectum some three or four inches, while the same proceeding as before was renewed, with the other sponge on the abdomen. Each sudden application threw the whole abdominal muscles into the greatest spasm, and each was immediately succeeded by a gush of fluid fæces. Three large basinfuls were thus got rid of. The operation, which had lasted about ten minntes, and which was attended with most intense agony, so much so that the patient writhed under it to a painful degree, was now suspended. The patient somewhat rallied from the deep prostration on the taking of some brandy, and expressed himself greatly relieved. He then fell into a quiet sleep. In the afternoon he had two fluid stools, and eight more during the night, entirely without pain. In a few days he was quite recovered."

Taking into consideration the whole details of this interesting case, to my own mind there is suggested the idea that the case was truly one of ilius, arising from a paralyzed state of the muscular coat of a portion of the little intestine. The injection was readily admitted past the affected portion of intestine, because all peristaltic action was lost; and it was not forced back on

removing the syringe, from the loss of tone and normal muscularity in the bowels. Electricity so applied was the prime remedy that saved his life.

*Constipation* attended with *inertia* of the bowels, and perhaps lost tone in the abdominal parietes, is a very frequent complaint. I have found electricity to be for it, often, a successful remedy. It is aided by the thorough method of *mellowing and deep-shampooing*, (which see,) as also by the internal use of podophyllum, ipecac, and conium, a quarter grain of the former, with one grain each of the latter, in pill form, and persevered in for some time.

Any form of electricity, if correctly and thoroughly applied, appears to be beneficial; but to profoundly electrify and then faradaize the abdominal muscles — first with primary, then with secondary, currents — is the most successful method. Use large sponge electrodes and a strong current, so as to produce thorough peristaltic motions, particularly when *both* sponge electrodes are placed upon or about the abdomen. But in the more obstinate cases, I carry the negative electrode, properly adjusted, far within the rectum, and then put on the current unsparingly, with now and then a recess; for twenty or thirty minutes.

When beginning a seance, the positive sponge may first rest on the upper spine for five minutes, while with the other bathe the bowels, beginning at the umbilicus, keeping it for only a quarter minute in any one place; so moving it by hitches over all the abdomen. Then remove the positive to the pit of the stomach over the *solar plexus*, and repeat it for another five minutes. Then take one electrode in each hand, with increased current, and move them hazing, or in part circles about each other, or as team electrodes; then finish the seance by mellowing and deep-shampooing. It may be repeated daily, or two or three times a week, until natural action is fairly aroused and established. No laxative medicine should be given. The regular action of the bowels should be *attempted* at stool, *at a certain hour daily*, whether a call or not. Prescribe this habit. Besides this, the patient should avoid cheese, and toast, and claret; but eat plain, coarse food, (with fruits and meat only once a day,) as corn-cake, hominy, *gray-bread*, oat meal, or moist rye bread, with

pumpkin or molasses, until the motions are prompt and sufficient.

Dr. Treusseau, of the *Hotel Dieu*, Paris, recently published a paper in which he strongly urges the profession to the more frequent employment of "electro-therapeutics." He says, "I consider this *class of remedies* particularly indicated in many of those cases where there is reason to suspect *a general want of tone in the bowels*, as in the delicate, the sedentary, male or female, and in other cases, indeed, wherever there may be suspected a *want of tone* in the parietes of the abdomen, or muscular coat of the bowels themselves in consequence of great or long-continued distention; or, in short, where the constipation can be referred to an undue secretion of gas or flatus, which in itself, by causing habitual over-distention of the bowels, and likewise of the hemorrhoidal vessels, diminishes their natural contractile power; also producing piles and other local weaknesses." (See pp. 466–470.)

Dr. W. Cummings, an English physician,* testifies that electric currents, in his hands, speedily brought about the cure of very many cases of *habitual constipation* which had resisted, in some instances, a great variety of treatments. Thus speak many other good authorities. Now, we reckon, that if habitual constipation can be uniformly broken up, and a more natural state brought about that is abiding, so that the bowels are more moist, both on the mucous and serous surfaces, that their calibre and place are more natural, that there is more natural peristaltic action of the intestines, that the muscles of the walls of the abdomen are toned up to symmetry, and this brought about by only such simple means, with little trouble and less expense, — is surely worthy of our attention and trial. It certainly has been my own experience during twenty years of general practice, that no such uniform, or, rather, frequent results, characterized with such permanency of relief for this most troublesome condition of many people, have ever attended any other sort of medication or regimen, either adopted by me or any one else. To be able to reëstablish the habitual, natural movements of such flabby bowels as have been irregular and "behind the time" for

* London Medical Gazette, vol. ix. p. 969.

years, is an achievement any way and every where. True, there are persons who from carelessness neglect to be punctual at stool, or who by unwise habits of living, or from a morbid appetite for quack medicines, for tobacco, "lager bier," cheese and crackers, for smoked meats or dried herrings — of course, will be obstinately constipated, or alternately relaxed. But there are, besides, a multitude of others, who, notwithstanding careful living, punctual stool habits, and most strenuous efforts, perhaps, over and beyond a sedentary business, which, indeed, they must continue to follow, are still suffering from a general weakness of the whole abdomen, or a torpid state of the intestines themselves, but which is most usually ascribed to the liver! Now, for these, which, by the way, constitute an enormous class, there are no other patients where this medication is more indicated than for such when correctly practised.

*Intestinal atony* is manifested as a *constipation*, arising from a want of peristaltic power of the contractile and muscular fibres of the intestines, or from a loss of tone or power of contraction in the muscles of the abdominal walls themselves. When both these states exist in the same case, *tympanitic distention* of the abdomen is very likely to be the most troublesome symptom. When neglected, it may become extreme, and threaten life by asphyxia from upward pressure. For all these states of atony I apply the sponge electrodes with Faradaic currents, first to the spine and then to the regions of the abdomen, never allowing the electrodes to rest more than fifteen to twenty seconds at any one place. The *labile* motion is my most favorite method here; using all the strength of current the patient can tolerably bear, and thus, as it were, *bathing the bowels with electricity without removing the electrodes*. I could here report any number of cases to illustrate this; but as the treatment is so similar, and yet influenced and varied in each case according to the general and special principles laid down in this work, that I forbear, simply adding, for example, that the *positive* electrode is usually placed upon the cervical or dorsal spine, while the *negative* is planted for a quarter or a half minute at a time over some portion of the colon, and then removed from place to place by being slid along without being taken off.

Dr. Robert Christison has employed galvanism in various *atonic* states of the abdominal viscera, and gives the following case * as an illustration of his views of "*extreme constipation in elderly people:*" "In the case about to be related, the patient had not had a stool for many days, which was his habit. On first seeing him there was no suffering. He seemed a fresh, vigorous, and active old gentleman. He took his food tolerably well; the pulse was natural; the tongue only a little furred. The abdomen is much distended, especially in both the iliac regions, where there are two large, prominent swellings projecting laterally much beyond the pelvic bones. There are, also, irregular swellings at different parts of the abdomen, especially in the track of the colon. Over some of these points percussion is quite dull; over others it is tympanitic.

"It was judged unsafe to give him active purgatives by the mouth at once, in case of the great gut being firmly obstructed with hardened fæces; therefore a turpentine injection was first properly administered to him by a student. The result was 'a prodigious discharge of fecal matter of all degrees of form and consistence.' Much of it was composed of very hard *scybalæ*. A dose of active cathartic was now administered after this forerunner, which brought away also a great mass of feculent matter. Active cathartics had frequently been repeated, but still the belly continued in the same state, presenting especially the singular enlargement and overlapping of the iliac regions.

"It was apparent that, owing to long continuous distention of the bowels with fæces and gases, *their muscular coats had lost their tone*, in some regions at least, and especially in the cœcum and the descending colon. It was then proposed to resort to electricity for relief from this sort of paralytic condition of the bowels; which suggestion was at once carried into effect. It is now more than twenty-five years since galvanism was recommended as a useful remedy in cases of obstinate constipation. We can easily see that it may be useful — and, too, upon what principles it acts. The earliest way or method of using it was by guiding the galvanic current in the direction

* Monthly Journal of Medical Science, Sept., 1858, p. 252.

*from* the mouth *to* the anus; and in this way it seems to have been most effectual and prompt, at least in some cases. But its action, to be effective in this manner, is rather disagreeable. But ulterior observations have shown that passing the current in various directions through the abdomen itself, may be quite sufficient. This remedy seemed to be the more adapted to the state of our patient *after* the bowels had been thus cleared out, for it acted upon them with wonderful energy and success. After this current had been passed for some time, directed from the back to the bowels, as well as from side to side, he had, in an hour after, a copious evacuation. In three hours he had another, and next morning a third. Flatus was also discharged in abundance. The abdomen contracted and fell greatly, but still not completely. The pain of the galvanic action, however, had been so great that the patient begged to have a day's respite. On the second morning, however, this remedy was again applied, but more gently; and then again on the alternate mornings subsequently. He acquired by this means a daily discharge from his bowels, and sometimes two. The abdomen became more natural in size and form. Since those days he has had *a natural* evacuation every morning, and without aid, either from laxative or galvanism. He was dismissed, I should have said, after receiving fourteen treatments.

"This is a case," says Dr. Christison, "which gives an excellent illustration of the influence exerted by galvanic currents over the animal *functions*. It appears to me to hold out a probability that the same remedy may prove serviceable in restoring the tone of the intestinal muscles in other forms of troublesome chronic flatulent distention of the abdomen."

Dr. W. Cummings, of Edinburgh, gives the following graphic description of cases of his experience in the use of electro-magnetism in certain states of the bowels: "We are often consulted," he says, "by patients who, at the first glance, convey the impression that *they are imperfectly nourished*. They have an emaciated appearance. In detailing their symptoms, they lay great stress on a feeling of 'all gone,' or, rather, a faintness at the epigastrium; they complain of exhaustion there. They generally next direct our attention to a more or less *fixed*

*pain*, either in the left hypochondriac or iliac region, sometimes both, but more frequently in the latter — a pain from which they are rarely exempt, and which is sometimes very severe and acute, though more often annoying and irritating. If they have ever been induced to apply a mustard poultice to the seat of pain, they dwell on the relief, great, though temporary, they have experienced from it. The stomach, in most of the cases I have seen, has not been irritable; it commonly retains and digests the food; but pain is frequently felt in the course of the colon, in a period varying from an hour to two hours after eating. The bowels are at one time constipated, at another lax, in the same person. Some are uniformly costive, others more frequently loose; but in all (*and this is the characteristic mark of the disease*) there is a peculiar membranous, fibrinous, or jelly-like matter discharged from the bowels. In some cases, it is stringy; in others, tape-like in its form; in others, again, it is in small masses, resembling fat or stiff jelly; while, in the milder cases, it is more diffluent and gelatinous."

That this disease has, from want of proper and actual examination of the intestinal *evacuations*, frequently eluded observation, I know too well from my own experience, and that it has consequently been maltreated does not admit of doubt. The last thing the patient will mention, (if indeed he mention it at all,) is the characteristic discharge. When the doctor directs his or her attention to it, they will hesitatingly admit that they may possibly have remarked it; nay, even when they are informed that it appears with every stool, they will often fail to discover it; and hence no practitioner should rest satisfied, when he has reason, from other indications, to suspect this affection, till he has *himself* examined the fæces most carefully, particularly while *separating* the fluid from the solid matter. In the former, as they are being poured off, he will rarely fail to discover flakes, or shreds, or even small masses; these, if discovered, will lead, at future opportunities, to the detection of larger and more unmistakable portions of this abnormal secretion. To take the *report* of the appearances from the patient, is, in too many instances, the surest way to deceive both him and yourself. In addition to this, there is not unfrequently

(but not always) a discharge of blood from the bowels, and that, too, *where no hemorrhoids can be detected.* Almost uniformly, *there is excruciating pain during evacuation, and always a feeling of exhaustion for some time after.* In most of the patients, there is a peculiar expression of countenance, so striking, that one who has understandingly seen many such cases can with tolerable certainty tell, without more minute examination, what the nature of the complaint is. It is an expression of anxiety and irritability, quite different, however, from that which usually marks organic disease. You must not conclude, however, as is too often the case, that your patient is laboring under an *incurable* malady. Scarcely less characteristic of the disease than any of the preceding symptoms is the *state of the mind.* In all there is more or less nervousness, greatly increased towards night, sleeplessness, or dreams of an unpleasant nature, which is almost invariable. One lady was troubled often with spectral illusions.

Professor Simpson has observed that in most of these cases that have come under his notice, there is *a deficiency of memory in regard to words.* The patient knows what he wishes to express, and is loquacious, but cannot find the desired expression at the moment. In my own experience, I have not observed this so frequently; and certainly in very many cases it is wanting; this is therefore not invariable. When the affection has been of long duration, (and too frequently this is the case before we are consulted,) the *mental irritability* is very great, and perhaps confirmed; and what is more painful still, the patient's feelings and views are quite perverted and distorted. It is unnecessary to add, that *they are miserable in themselves*, and where the nature of the affection is unknown to, and due allowance not made by, their companions and friends, *they are truly a cause of misery to others.* They are quite sensible that they are not what they formerly were; that they are changed in temper and condition for the *worse;* they feel, moreover, that they have little control over their mental state, and are apt to fall into a condition of great depression and despondency. If I were to express their internal feeling in few words, I would say that "they have a mixture of irritability

and despondency, relieved, from time to time, by happier feelings; but that those latter are of comparatively short duration."

This state of the bowels is vastly more common in the female than in the male sex, though by no means uncommon in the latter; and in the former it is very often *accompanied* by dismenorrhœa, and occasionally, too, by the membranous form of that affection. For such I prescribe *formulæ* 18 and 29.

The primary, and I believe indispensable point for cure is, first, a total, or almost "*total abstinence from purgative medicines.*" With this view, I was till lately in the habit of relieving the bowels every third or fourth day by *enemata* of simple warm water, or with the addition of a table spoonful of salt and molasses, or oil, and perhaps every ten or twelve days a dose of laxative by the mouth. These means, simple though they be, *actually do mischief;* and therefore it was desirable to discover a mode of effecting the object, without the disadvantage of its being, at the same time, an irritant and debilitant.

*External counter-irritation* is the second point; and this, from shampooing, or a mustard poultice, or both, every night or second night, gives considerable but only temporary relief, which, however, was always most grateful to the patient. But in very many instances it failed utterly, and where it did benefit the relief was usually transient.

"Circumstances which I need not at present detail," says Dr. Cummings, "led me to surmise that electro-galvanism would accomplish both those indications of treatment, viz., counter-irritative and laxative, *without the disadvantages* to the patient with which other means are chargeable. The results of its use, in a considerable number of cases of this *intestine disease*, warrant me, I think, in affirming *that electricity is competent of itself to the cure of almost every such case*, and that if aided by a *unique* internal medicine, which I shall refer to presently, it will *cure* both *certainly* and *speedily*.

"In the first place I find it acts as an aperient, seemingly by its action on the intestinal muscular coat, as well as the secretions of the mucous membrane of the bowels. *In every case in which I have used it, this has been the effect;* and if it had no

other consequence beyond this, the advantage from it is *prodigious;* for, as in a multitude of instances, this ultimate affection has been traced to the use or abuse of laxative medicines taken as a cure; hence, since during the treatment of this affection, even the mildest aperients irritate the mucous membrane, and so far aggravate (temporarily) the disease, therefore the evacuation of the bowels, by any other means that do not irritate nor yet exhaust, but, on the contrary, can invigorate, is obviously of vast consequence. But the electro-magnetic currents do more than this; for, secondly, it induces such a changed state of the bowels as prevents the further formation of this peculiar secretion; that is, it restores the bowels to a more healthy condition. I purposely avoid using expressions which might involve a theory as to its mode of action, and do not profess to tell how this result takes place. *The fact itself is undeniable.* Thirdly, electricity supersedes all counter-irritation. The pain in the side, for the removal of which the counter-irritant was employed, is relieved by an application of the galvanism for at least twenty-four hours; in many cases for a much longer period; but as the agent is applied once a day, where no contra-indicating cause exists, till the disease is removed, it may be said that *the pain is abolished* at the same time.

"Electricity can of itself effect a cure; but I have generally combined it with the internal exhibition of *tar*, and have thus effected cures in a much shorter time than by either of these means singly. For some time I was in the habit of giving internally the nitrate of silver, or cod liver oil, as circumstances directed; but latterly, I have confined myself simply to the simultaneous administration of *electricity* and *tar* for these cases, as suggested first, I believe, by Dr. Simpson, and have found that it, of all internal means for these cases, is by far the most prompt and permanently effectual. This relieves the feeling of exhaustion at the epigastrium, imparts an agreeable warmth, promotes appetite and digestion; but the tar, by itself, is long in effecting a cure, even in slight cases, in all the trials I have made of it. The plan I have hitherto adopted has been to give the tar in the form of pill or capsule, thrice a day, while the electro-

galvanism is repeated for a quarter of an hour, daily, the intensity being increased from time to time. Steady perseverance for a season is requisite. With this method, according to my experience, the case must be obdurate indeed that will resist a cure.

"One remarkable fact connected with the treatment by electro-magnetism is, that it detects the very portion of the bowels where the greatest amount of irritation exists — a knowledge which manual pressure often fails to elicit; for it is a singular truth, that where the instrument is in action, extreme tenderness is complained of in more than one well-defined spot or tract, of which usually the patients were not previously aware, and that, perhaps, quite distant from the regions to which the attention of the doctor is directed, as the seat of pain. It is extremely interesting to observe how this tenderness, after a time, from the continued use of electro-magnetism or galvanism, diminishes, until a mere point is fixed upon, as its seat, and how this also is removed; after which the disease may be said to be actually *extinguished.* Yet I have seen reason to persevere, at more distant intervals, in the application of this agent, for the sake of confirming the recovery by strengthening the nervous system, and conducing to the self-regulation of the bowels."

The foregoing testimony of Dr. Cummings on this point is extremely valuable; indeed, I know of none more so. But I am inclined to think that the harassing pains attending these cases are, in part at least, seated in the parietes of the abdomen — a muscular hyperæsthesia that, though a part of the affection, should be correctly designated. As the abdominal viscera are always a little slower to respond to the electric influence than are voluntary muscles, so, when treating here, and the *positive* electrode is upon some part of the spine, while the negative is upon the bowels, the latter must be *compressed and retained for some appreciable time in a given spot* in order to make any real and abiding impression upon the underlying bowel. This is all-important, even while the electrode that is on the back is being moved up or down, as also when both electrodes are applied and embedded in the flanks of the abdomen itself.

*In chronic dysentery or diarrhœa* with atony, where the chief feature of the case appears to be debility with asthenic plethora

or congestion, and hence a morbid secretion of the mucous membrane of the alimentary canal, electricity applied over the whole abdomen, and the solar plexus especially, first for profoundly electrifying and exercising the abdominal muscles, and then by *faradaization through the wire brush*, for reflex effect on the internal viscera, together with the internal use of ipecac in minute and repeated doses, is the most effective treatment, in a certain class of cases, for a speedy and permanent cure.

When ipecacuanha is given in such chronic bowel affections in large doses, it appears to produce the same relaxation of the mucous membrane as it does of the system in general. There is produced a copious discharge of the secretions of that membrane, which relieves it of the tension caused by the congestion and effusion of lymph, much the same as we produce on the surface, for instance, when we scarify an erysipelatous tension, and thus prevent the destruction of tissue and ulceration. The excreted fluid loosens and lubricates any lingering *scybalæ* that may be in the saccules of the colon, while the general nausea aids the electricity to overcome the spasmodic actions of the muscular coats of the bowels, and allows the natural rest, and the peristaltic actions to resume their rhythmical periods of motion. For obstinate cases —

Give first a half or one-grain pill of opium, and immediately make the application of electricity over the stomach, liver, and whole abdomen. Then order that about one hour after the seance, the patient take three, six, or more of three-grain pills of ipecacuanha, and go to his lounge or bed; the latter is better, for there will ensue considerable nausea and perspiration; the pulse is more full and soft, and less frequent, and there may be vomiting, (which is to be avoided if possible,) and he is to spend the time in sleep if he can. In fact, the horizontal posture should be maintained as much of the time as is consistent in the case. Repeat the electricity and the ipecac every other day until the discharges become natural. Feed him on flour porridge only. Let it be made of half milk and half water; and to a quart, only a table-spoonful of flour, previously moistened, is to be added and boiled; after removing from the fire, add a tea-spoonful of

carbonate magnesia, finely pulverized, and nearly half as much salt. This must be sufficient for twenty-four hours, and to be persevered in for three days or a week; then toast and tea.

When the patient has no more tenesmus, or abdominal pains, nor a stool for twelve or twenty-four hours, stop the opium and ipecac, and let him out to walk or ride; but repeat the electric seance every day for a week or ten days more. Some are thus cured in two days; others in three or four; others may require a week or more. In refractory cases prescribe *formulæ* 9, 39, 18, or 29, and apply the ice-bag along the dorsal spine; not immediately to the skin, but over folds of cloth, so as to be only cool, but *long continued*, and gradually left off. This plan will save many a miserable and otherwise hopeless sufferer.

### *Asiatic Cholera.*

*Cholera*, when appearing fully developed, must be recognized as a specific disease; still, we can scarcely separate it from certain forms of maladies, as diarrhœal and dysenteric affections, which almost invariably precede or attend this epidemic. These affections are termed *choleraic diarrhœa* and *choleraic dysentery*. We are told in the able report of the English Board of Health, "that in every European town where the cholera appeared, it gave warning of its approach by the increased prevalence of zymotic diseases; such as influenza, scarlet fever, dysentery, and diarrhœa; and that the last named, as a premonitory symptom, invariably prevailed extensively before the cholera broke out." This corresponds with our own observations. But it is usually some days or weeks after the appearance of these bowel complaints, that the cholera appears in pestilential form, as characterized by *rice-water discharges* from the bowels, vomiting, prostration, cramps, huskiness of voice, rapid emaciation, a bluish, cadaverous-appearing skin, and speedy death by asphyxia.

On the whole, from the facts before us, we are led to regard the great majority of cases of cholera, and choleraic diarrhœa, *as referable to the prevailing epidemic atmospheric influence;* while only a minority of cases spring from contagion; and therefore the efficient cause is partly contagious, and partly meteoric

or atmospheric. Yet there is, perhaps, no epidemic distemper so readily induced by accessory causes, or more readily prevented by avoiding them, than cholera. *Intemperance in eating and drinking*, and especially unripe and over-ripe fruit, stale vegetables, indigestible food, foulness of person or premises, worried or depressed mind, fatigue, wet, and cold, or long exposure to the contagion, — any such thing may or may not induce an attack of cholera, i. e., *while the atmosphere is predisposing to it.*

Godliness, faith, temperance, and cleanliness are the cardinal preventives. Ice in a dry rubber bag to the spine, and dry heat to the extremities, with the internal use of equal parts of tincture of opium, capsicum, and camphor, in tea-spoonful doses, and repeated until relief, with electricity applied smartly over the vital organs, *are the cardinal remedies*, in which, from experience, I have the utmost confidence.

In 1854, Dr. C. Meinig called the attention of the medical world to the great value of the primary current of galvanism in the treatment of *choleraic diarrhœa*. Where the symptoms are violent, bowel discharges are attended with pains, cramps, and spasms, or movements and *borborygmus* in the bowels, with swashy diarrhœa, vomiting, cold sweating, cramping sensation in the legs, &c. The method he pursued in such cases is thus given: —

The *positive* electrode of his portable (and powerful) compound galvanic battery was first applied to the *spine*, between the shoulders; the *negative* pole being placed on the abdominal region, and occasionally moved higher up or lower down, according to the varying seat of the pains, and coldness in the bowels. The good effect of the current was uniformly perceived at once, in a feeling of warmth and tone in the bowels, the pains uniformly and entirely disappearing in about half an hour; both the diarrhœa and vomiting subsided only gradually, in the course of from two to five hours, when slight weakness was left, the urine reappearing shortly after the application of electricity, probably through the action of the current on the urinary organs. He says, "I have witnessed these results in eight cases, one of them finally being in my own per-

son; in which case, to attest my confidence, I purposely abstained from employing any other remedy whatever. It was here often found necessary to communicate the current to the abdomen by means of a metallic plate electrode, of sufficient size to cover the whole abdominal region, as the patients complained that the warmth was limited to the exact position of the previously used small disk, and did not sufficiently pervade the whole abdomen. In one or two cases, I observed the remarkable circumstance, that while the diarrhœa lasted, the pricking sensation at the negative pole was almost nil; whereas, after the disappearance of the complaint, the skin was blistered, in about a quarter of an hour, by the power of the current. I certainly look upon these observations as of sufficient importance, at the present juncture, to induce physicians to test their validity, the more so as it can be done without great trouble, and without precluding the use of other remedies, and as the successful results here stated may very easily be accounted for. Whatever may be the difference of opinion as to the *cause* of cholera, and the nature of cholera or its symptoms, and consequent treatment, two points will be conceded by most thinking men.

1. That it is of the utmost importance to keep up the power of the central, as well as of the digestive system, so that, if diarrhœa there must be, the other functions are disturbed as little as possible.

2. That in this disease, that remedy is the most preferable and certain of effect, which is the most *directly* applicable, and the most independent of the disturbed digestive functions.

In sending a continuous mild stream of electricity (here using no interrupted or shock current) from the spine to the abdomen, I *vitalize* — keep up the power of — the whole central and digestive systems, and by keeping in action all functions, I prevent the diarrhœa from taking a virulent and passive character. I do this instantly, and independently of digestive functions, strongly or mildly, continuously or intermittingly, at option. All the effects purporting to be produced by the means generally employed, are thus produced much more perfectly and instantaneously by this simple application. However, volumes

of reasoning will never supply the test of experience. Therefore let electricity be fairly tried. Dr. Meinig says, —

"With regard to cases of collapse, I cannot speak from experience, never having witnessed such a case. It is, however, a fact witnessed by me dozens of times, and very easily demonstrated, that *spasms* and *cramps* of the *ordinary* description cease in a few minutes under the influence of strong primary *continuous* (not shock) currents passed along down the spine and the contracted limbs; and with regard to the maintenance of irritation in any given part of the body, it will be obvious to every one that no other means at command can bear the most distant comparison with electricity, for such purpose.

"In cases of collapse, I would fix one disk on the spine, the other on the abdomen, as above stated; and, in addition, I would send the strong continuous current from a galvanic battery first along down the spine, and then from the spine along the cramped or contracted parts, also through the liver, stomach, and bowels; a few shocks to be used only where it was necessary, and *but momentarily*, to stir up the whole system — in fact, simply to keep up life." The key to understand the relative bearing of the foregoing treatments is found in those words where Dr. Meinig says, "The skin was blistered in fifteen minutes by the power of the current employed;" that is, he employed a very powerful primary current in these extreme cases, and produced such uniform good results.

From the theory of cholera as published by Sir James Murray, in the London Medical and Surgical Journal, in 1832, and since amply confirmed in many parts of the world, it is to be concluded that the judicious use of electro-magnetic or galvanic passes, patiently persevered in, through the *respiratory and spinal nerves* is one of the most essential adjuvants that can be employed *during collapse*, or that state of *passive electric abstraction* which ought to be treated much like suspended animation.

*Dropsy*, in very many instances, where the œdema, or the accumulation of fluid in the cavities, is not the result of fatal organic disease, both Galvanic and Faradaic currents have proved highly serviceable — in some instances independently, in others

as auxiliary. This is rational. We know blood flows out through the moss-like frir into the capillaries, and so on again into t of veins in its return back to the heart an intricate pass from the ultimate twigs of mate twigs of veins, the blood appears t( moisture by the process of exudation an the various tissues are lubricated and *no* mysterious and intricate instances, eithe more watery, or poor in iron and salts, o the state of the tissues, this exuded or *debris*, does not get back into the veins, l in the cellular tissue, and this is termed ciples of endosmosis and exosmosis, it is moreover, we can comprehend its rela vitalized electro-nervous battery of the or

In cases of anasarca, particularly of th( smart primary or secondary currents, a approximating, and as ceaselessly moving produce muscle fibre and capillary cont followed by warmth and strength, and con a disappearance of the dropsical effusion. a daily wash in warm water, and then the by a splash of cold water for one moment

## CHAPTER XI.

### FEIGNED NERVOUS AFFECTIONS, SEA-SICKNESS, ALCOHOL, TOBACCO, &c.

*Feigned Nervous Diseases.* — Here are required both science and tact. We must distinguish between *real*, *imaginary*, and *feigned* diseases. No matter how presented, represented, or suspected, every such case should be patiently, yes, and sometimes repeatedly examined before pronouncing a diagnosis, or prognosis. Skill must be mingled with charity. It is wise, safe, and humane to fairly assume that the patient *is sick*, or in pain, or is disabled, until we can satisfy the patient, as well as ourselves, that he is feigning disease, or is exaggerating his ailment. That is, if there can be an error, let it be in his favor; not that it is kindness to allow a person to settle down into a morbid invalidism, with imaginary or induced disease, but act so as to spare any unnecessarily severe treatment.

Many perplexing questions of this sort, however, have come under my own observation. I find that where a case is suspected as either an exaggeration, or a pure feigning of disease, or disability, the best method is, not to accuse them abruptly, but rather with a due consideration, and take what they say for granted, — the physician showing doubt, or difficulty of understanding, as he may judge best, — and then proceed to apply the remedies seriously and heroically, giving the patient to feel that we take great interest in his case. He will find it hard work to persist in attempting to deceive his medical attendant, whose skill and judicious treatment, according to representations made, command his respect; or to persist in imposing upon the unremitting attentions of the faithful nurse.

Besides, we have a wonderful "*rallying power*" in the faradaic current, *when given through the wire-brush electrode.*

Whether feigned disease, or not, as pretended rheumatism of the back, for instance, it does no injury, but will be likely to be very disagreeably felt. If repeatedly and vigorously *pursued*, or *promised*, (when there is strong reason for suspicion,) it will generally prove an *argumentum ad hominem;* and so convincing is it to the would-be patient, that he very soon concludes to adopt the old maxim, "*The remedy is worse than the disease.*" He will probably have a very rapid recovery.

For anchylosed joints, crooked limbs from contraction of muscles, and the like, we must resort to anæsthetics for test. For excessive local pain, (for feigned pain is both excessive and protracted,) when other means fail, we have hypodermic injections of morphia, which, in the truly sick, invariably show *temporary* relief. For numbness, or paralysis of any limb or part, we have localized faradaization, the cautery, or electro-puncture needles. For exaggerated or feigned distress in the stomach, or about the heart, give the tincture of assafœtida, in tea-spoon doses, and often repeated; but, on leaving, give orders to the nurse, (*accidentally in the hearing of the patient,*) that, as the pain and suffering seem to abate, to be sure to give the medicine less frequently, or stop it altogether. If the patient cannot or will not swallow, pour it into the mouth any how, between cheek and teeth, if no better.

In suspected cases, the situation, condition, and surroundings of the patient may throw light on the subject. That is, try to ascertain if there be any reason for feigning disability. What is the condition of the patient's mind? Is he at school, or an apprentice, or a soldier, or sailor, or in the employ of a factor, so that he might wish to shirk work, or escape duty or danger? or is he a partner in a concern, and might wish to avoid some responsibility? or may he have hypochondriasis, or what we might term *a morbid disgust for business?* or may she be a nervous or hysterical person, who may be tempted to extort sympathy, attention, or indulgence? Now, some such condition *about* the patient, as well as in the patient, may become an accusing witness in the case; bearing in mind all the while that it is a very cruel act to carelessly misjudge a truly sick person. But, actuated by the golden rule of doing precisely as we would

have others do unto us in like circumstances, we are safe and justified; and in recent cases we may be successful and useful.

*Feigned* diseases, however, are not the worst of evils. I am sorry to say, — though every one already knows the fact, — that there are feigned, imaginary, and exaggerated *doctors*, as well as diseases. But when a medical man now, in these days of general knowledge, and in a city of these United States, having the title and position that ought to command the confidence and coöperation of the profession, and the patronage of the public, will put forth, in the weekly and religious newspapers, or allow to be put forth uncontradicted, such jargon, sophistry, or clap-trap stuff as the following quotations, I feel sure that the profession will pardon me for this seeming digression, that I may here set up a beacon, or anchor a buoy — for buoys and beacons have their uses, as well as monuments:—

"The faculty of the Institute claim to achieve the greatest triumphs among *incurables* from other establishments. They defend the new system, and challenge investigation, submitting the following synopsis of their practice. It consists, *First*, in the *scientific* use of dynamic or motive electricity, divested of the shocking principle, and *charged* with the most valuable specific balsamic remedies; and also in the application of *unmixed* electricity, with its virtues multiplied a thousand times. . . . *Thirdly*, in the occasional use of the Swedish movement cure, and of hydropathy. . . . *Fourthly*, in the use of *electrified medicines*, which, from being subjected to electric action, have had all their tonic, recuperative, and disinfectant properties *quadrupled*. They are mild and painless in their operation, pleasant to the taste, and take effect almost instantaneously. . . . The new practice consists, in part, in the disintegration of *other* metals by other acids," (referring probably to the metallic plates of the galvanic battery,) "thus producing other remedial influences. These are applied especially in nervous, pulmonic, and renal complaints." Shall I quote more? "Out of 3600 persons registered during 1864, there were 2786 cured; and 446 are described as benefited." Such patronage and success, and yet they advertise!

Well, this is what disgusts, and has disgusted, intelligent,

thinking people, in the profession and out, and so prevents some of the older practitioners from learning, much less trying, the remedial effects of electricity. This course, on the other hand, is just the way to open a door for quackery; for the remedial power of electricity does undeniably exist; and if intelligent medical men will not understand it, nor employ it, others will use it, and abuse it, or rather the patient, and the public confidence. But this is nothing new. All this *feigning*, *imagining*, and *exaggerating* is old and stale. A hundred years ago and ever since, electricity (like many other invaluable articles in therapeutics) has been a hobby-horse for impostors; "*medicated electricity*" and "*electrified medicines*" were then boasted of, as now. (See p. 90.)

*Cold Feet and Hands.*—The attention of the profession, I believe, was first called, by Dr. Robert Dewitt, to the use of *hot* water as a remedy for cold and profuse perspiration; and, if repeated for cold sweaty feet, or for cold moist hands, it is often found to work a cure. If *cold* water be used, he says, the parts bathed remain cool for some time, and then become gradually warm or glowing; if the water is *tepid*, the flesh is made chilly and flabby; if *warm*, it is left perspiring; if *hot* water be used, it is left hot, red, and dry, and continues so for a considerable time.

The terms *cold*, *tepid*, *warm*, and *hot*, are merely relative. What would be warm to one would be lukewarm to another person; but when I say *hot* water for this purpose, I mean water as hot as can possibly be borne without pain. It may be used, according to his plan, by immersion, or by sponging, until the parts so treated are hot, red, and tingling with heat. A good wipe with water at 130° is easily borne; but for immersion the heat must be less; the sensation here is the true guide. Young persons, from thirteen to thirty, often endure great discomfort from this cause, and they may thus find relief. Such cases generally also require free purgation, tonics of quinine and iron, and out-door air and exercise. Thus the health is pretty sure to be improved.

*Electricity* should be applied every evening, or so, *to the loins*, and the legs below the knees, or to the cold hands and arms below

the elbows, — both through sponge electrodes, to exercise the muscles, and then through the wire brush, by painting movements, until in a glow. Follow this with *mellowing and deep-shampooing*, (see p. 453,) or by *slapping*, as with a ruler or leather strap, or by a brisk rubbing, as with a coarse towel, until red and warm. Every such case can thus be cured.

*Sea-sickness* is probably a form of *ganglionic derangement or hyperæsthesia*. Most writers on sea-sickness have considered it due to a hyperæmia of the brain and spinal cord, or to a morbid condition of the gastric nerve.

In a paper read before the Royal Medical and Chirurgical Society, in January last, Dr. J. Altheus shows that sea-sickness is, in reality, caused by "anæmia of the brain and the cervical portion of the spinal cord, arising from insufficient power of the heart, and thereby a general increase of reflex excitability throughout the system is brought about. The first and most constant symptom is not retching or vomiting, but vertigo, which is the most severe in the standing posture, and is at once relieved by a strictly horizontal position. There is evidently a deficiency of blood in the great nerve centres.

"The increased reflex action is proved by the increased sensitiveness to light, sound, touch, &c.; but this is greatest in the stomach, the degree of which depends upon posture more than upon the condition of the stomach, or of the greater or less vital power. This increase of reflex excitability, after a time, is followed by marked diminution of it, so that there is great torpor, and a profound indifference. The heart, in consequence of the ship's motion, is primarily disturbed, and becomes unable to propel the blood as usual. The blood accumulates in the chest and abdomen, producing a sense of pressure and heat." *Persons with a strong heart and a slow pulse generally suffer little or none from sea-sickness.* Irritable people, with a quick or excitable pulse, or a tendency to palpitations, are more liable to be sea-sick.

*The treatment*, then, should be directed to facilitate the flow of blood to the head, and to strengthen the heart's action. To this end prescribe one grain of quinine and half a grain of opium, every eight hours; to take a horizontal posture; to eat

well-seasoned meat or beef tea, and take with it small, equal doses of brandy and water.

*Electricity*, too, if at hand, can be made the most serviceable use of here. While the patient is lying on his back, apply a brisk faradaic current, through sponge electrodes, gliding them about, first over the region of the stomach, heart, and solar plexus especially, and then over the whole thorax and abdomen, for ten or fifteen minutes; then finish by employing the wire brush smartly, as negative electrode, in painting movements. This may be repeated every hour, or less, until well. He should eat regular meals. But, on going on board at first, it is prudent to have the stomach and bowels free, eating plainly, and have a daily stool.

Next, we shall introduce a sub-chapter on alcoholic spirits, and another on tobacco. But why here, in such a work as this? Because, in treating nervous diseases, we have much to consider with reference to these articles, viz., their physiological, therapeutical, deleterious, and *poisonous effects*, thus complicating some of the most serious and profound nervous disorders; and young medical men should be possessed or reminded of these facts.

## *Alcohol.*

*Pure spirit*, in the form of brandy, given to perfectly healthy men, who have never taken liquor, and observed very minutely, was found, in accurate experiment, by Dr. Edward Smith, to produce, first, lessened consciousness, and lessened sensibility to light, sound, and touch. Next, there came a peculiar sensation of stiffness, with swelling in the skin, which was noticed particularly in the upper lip and cheeks. There is, also, as the *early effects*, a relaxation of the dartos, and other muscles connected with the reproductive system; as also relaxation of the sphincters of the bladder, and the consequent frequent desire for micturation.

Dr. Hammond, formerly the physician-in-chief of our armies, made trials for ascertaining its influence on an under-fed and on an over-fed man; i. e., where the body was losing weight during deficiency, and where it was gaining weight during full feeding.

He found that in five days, while under just sufficient diet, he grew in weight about a half pound more, when he took half an ounce of pure alcohol with each meal, than in the five days while he omitted it. This was attended with diminished excretion of carbonic acid from the lungs, less urea and sulphates from the kidneys. There were also impaired appetite, and indisposition to activity.

The use of a similar quantity of alcohol was then repeated, with such a diminution of food taken, as had been ascertained to be capable of reducing the weight at the rate of a quarter of a pound per day. And here came into play *the true use of spirit*, in one sense; for it was found capable of not only arresting this diminution, but even of causing a slight increase in weight, while at the same time the health remained perfect, the spirit and feelings vigorous. In contrast to this, stands the further experiment made while a superabundant diet was adopted, sufficient of itself to increase the weight of the body: the addition of the alcohol now, by restraining the waste and excretions, caused *headache, feverishness, heated skin, nervousness, and disturbed sleep.* These facts are fundamental; and are very important for medical men to bear in mind.

It would appear, then, that for perfectly healthy persons, alcoholic liquors are useful *only when the amount of food is insufficient*, or perhaps, where extraordinary exertions make a demand which the ordinary food cannot satisfy. Upon these premises we can base a rational opinion, and advise such persons accordingly. But when we come to the sick, at the bedside, and for the invalid, we must seek further rules to guide us.

Although health does not consist in the *predominant* vitality of this or that organ, nor even in the superabundant vitality of all, but rather in the good condition, general harmony, and perfect balance of all the functions, the consequence of toil, mental even more than corporeal, is to increase the destructive metamorphosis of blood, nerve, and tissue; and, in the large proportion of the working population, it is liable to increase it beyond a rate with which the glandular, the digestive, and the assimilative processes, *if unaided*, can possibly keep pace. An

over-fagged man has diminished appetite, and secretes not enough gastric juice to digest what little he does eat. True, he may recruit himself by long repose, if he can have the time; but it is easier, and more economical of time, to take a little spirit, and a short rest, during the latter period of labor, say after dinner; and thus prevent, in some degree, the metamorphosis of the powers of life.

But would not *a cup of coffee* do the same thing? If so, it is decidedly to be preferred. That coffee can replace the spirit, at least in a large proportion of cases, we do believe and know; but that spirit may aid some, where coffee would not, we are not as yet prepared to deny. So that, while we do not believe that the highest manifestation of bodily vigor, nor the most precious productions of the intellect, are elicited by the aid of alcoholic drinks, yet would the public weal appear to suffer if pure spirits were totally inaccessible; but probably very far less, relatively, than now, liquors being used so generally and indiscriminately.

*Alcoholic drink* affects mainly the mental portion of the nervous centre, through the ganglionic nerves. Some persons feel the peculiar stimulus in their head, *even while swallowing the liquor*, or as soon as it is swallowed. It can be absorbed through the skin, as well as through the mucous membrane of the human body; and it has the same effect as when taken in the ordinary way. I have seen individuals decidedly intoxicated by simply bathing a portion of the body or limbs in New England rum.

We owe to the French chemists the discovery of how very moderate quantities of alcoholic liquor can be detected in the excretions. If a man takes a glass of wine, or a spoonful of brandy, and then half an hour afterwards breathes through Dr. Massing's test apparatus, or if he has his urine analyzed, both secretions are found to contain the drug. Even by enclosing the arm of a person, after taking liquor, in an India-rubber bag, for twenty minutes, we can obtain the chemical evidence of its presence. On the whole, then, we think we are justified in the conclusion that the temporary metamorphosis caused by spirit is mainly, if not entirely, due to its anæsthetic action on the nervous centres. Probably the first steps of the degenera-

tion commence in the blood, and then in the organic functions, while the nervous system receives the greatest damage of all.

Alcoholic liquors, then, we are to understand, from all this evidence, act, physiologically and primarily, *as an anæsthetic — an actual diminisher of vitality in the nervous system.* But only under certain circumstances of debility does it act as a *conservator* of what diminished vitality is left, and thus aids deficient food, and temporarily prevents the excess of toil.

It is clear, therefore, that we must now cease to regard spirituous liquors as in any sense an aliment, or nutriment, inasmuch as it leaves the human body as it was taken into it; and does not, so far as we know, leave any of its properties behind. Physiologists have always taught, that large doses do immediately, and small doses after a time, depress the nervous centres. But what we wish particularly to remark is, that the primary action of any dose of alcohol is anæsthetic; i. e., acts directly, or ultimately, as an absolute diminisher of vitality. It is true, there is observed an increase of excitement, and in motions, and in the frequency of the pulse; but these cannot be regarded as evidence of augmented vital action; for of all patients some of those especially exhibit it who have the weakest hearts and nerves, and are the most enfeebled by disease. A diminution of force is quite consistent with augmented quickness of motion; indeed, may it not be said, that in involuntary muscles it implies it? Alcohol simply diminishes the transformation of tissue, or, in plain words, diminishes the wear and tear of body, only under certain circumstances.

With regard to the properties, uses, or abuses, of liquors, wines, champagne, cider, ale, or porter, we do not propose here to say anything; it is only with the *alcohol* they contain, and the physiological effects of it, and the poisonous drugs mixed with it, as found in *made* liquors, that we wish to establish a medical opinion.

*Chronic Alcoholism.* — By this we mean that peculiarly induced or poisoned state of the nervous system, that might properly be termed *whiskey poison.* It is due more to the *frequency* than to the quantity of the doses; consisting in a disordered condition of the whole mental, motor, sympathetic, and sensory functions;

assuming the chronic form from a chronic cause, and seriously predisposing to the most grave nerve disorders. It arises from the long so-called "*moderate use*" of intoxicating liquors. A table-spoonful, a mere swallow at a time, if often repeated, daily and persistently, is sufficient to produce it in a certain class of individuals; while in other persons ten times as much would produce no effects. Perhaps we cannot more graphically present the picture of the leading characteristics, so that you can readily discover these cases, than to just sum up the symptoms into classes: —

1. *Sleeplessness*, impatience, irritability.
2. *Headaches*, and other aches through back and thorax.
3. *Giddiness*, and occipital neuralgia, or *occipital distress*.
4. *Hallucinations*, hypochondriasis, hyperæsthesia, or *hysteria*.
5. *General debility;* i. e., a want of stamina; although the muscles may be plump and large, still it is true of them that they cannot endure.
6. *Dyspepsia*, from loss of tone in all the digestive organs.
7. *Difficulty of breathing*, choking, or spasms of the throat and chest; it being actually a spasm of the æsophagus and larynx. A spell of this class of symptoms is often followed, in either sex, by eructations and other sensations, as after true *globus hystericus*. It is in fact *a simple chronic delirium tremens*. Women may have the delirium tremens, but we are not so likely to see distinctive chronic alcoholism in the female as in the male, for in her it is blended with other ailments.

A slight degree of this affection is now and then met with among those in the higher walks of life, who only use *a little spirits genteelly*, or perhaps for their throat, or lungs, or stomach, or for sleep. In such we often find that the nervous constitution has been already so far affected, that now the slightest cause will be sufficient to startle or frighten him; or to produce giddiness or headache; or keep him from a portion of his night's sleep and rest, yet not preventing him from attending to his regular business. Now, such a case is very prone to a true attack of chronic alcoholism, from any slight cause, independent of drink, such as an attack of rheumatism, or bronchitis. And this

sometimes sets in a long time after the cessation of the habit of drinking whiskey, or other spirituous beverages.

*Treatment.* — The first thing to be done is, *to stop* that little alcoholic stimulus. The next is, to give the oxide of zinc, in two-grain doses, gradually increasing during a month to ten grains, taken twice a day, in a dessert spoonful of tincture of rhubarb. Electro-magnetism, applied from sponge electrodes, about the waist one day, thorax another day, abdomen the next, and back the next day, and so on, — *faradaizing* also, for five or ten minutes, daily, or every other day.

Out-door exercise, or riding; hair mattress bed; "early to bed and early to rise," and the results of one month's treatment will be, improvement in sleeping; mental depression and apprehension less; black specks, images, and crawling things no longer flit before the eyes; extraordinary noises are no longer heard, while the trembling hand becomes steady, and the patient can bear society cheerfully; gradually thereafter muscular power and nervous endurance are restored. But we fail to do our duty if we do not plainly give it as our professional opinion, that such a constitution should never more venture to dabble with spirituous liquors.

*Tobacco*, and its physiological effects on the smoker, are here introduced to set forth *the pathological results* that complicate so many nervous affections. We will condense what is to be said here, at least in part, from a very valuable paper by Dr. Richardson, and recently read before the British Association, London. We will thus in a few words show the products of combustion of tobacco, the physiological action of the various properties thus derived, and the relative effects of smoking on the organs of the human body. The products of combustion of tobacco are, 1. *water;* 2. free *carbon;* 3. *ammonia;* 4. *carbonic acid;* 5. an alkaloid called *nicotine;* 6. an *empyreumatic* substance; 7. a resinous *bitter extract.*

The water is in the form of vapor; the carbon is in the form of minute particles suspended through the watery vapor, giving to the eddies of smoke their blue color; the ammonia is in the form of gas, combined with carbonic acid; the nicotine is a *non-*

volatile body, and remains in the pipe and in the *moist end* of the cigar; the empyreumatic substance is volatile, and gives to the tobacco smoke its peculiar odor, and it adheres peculiarly to woollen materials; the bitter extract is not volatile, and only leaves the pipe or cigar by being carried along the stem in the fluid form.

The greatest variations exist in different kinds of tobacco. Simple tobacco — dried *leaves*, that have not undergone fermentation — yields very little free carbon, much ammonia, much carbonic acid, little water, little of nicotine, and little empyreumatic vapor, and an equally small quantity of bitter extract. *Havana cigars* yields all these products in abundance. *Cavendish* varies in different samples considerably; some, which dry readily, are nearly as simple as the unfermented leaf, while other moist specimens afford all the products in greatest abundance. *Pigtail* and *Cut*-tobacco yield every product most abundantly; the little *Swiss* and *Spanish cigars* quite enormous quantities; while the *Manillas* afford very little. The best of true *Turkish tobacco* yields most largely of ammonia.

The physiological effects of these products are as follows: The water vapor is innocent; the carbon settles on the mucous membrane of mouth, throat, and nose, and leaves an irritation. The ammonia and carbon together cause dryness and tingling of the membrane nerves, and increase the flow of saliva; if absorbed into the blood, as from excessive smoking, or even from little smoking in some constitutions, they render that fluid too thin, causing irregularity of the blood corpuscules; thus also are caused suppression of the biliary secretion, and consequent yellowness of skin; tobacco at first quickens, then reduces the action of the heart; and in young smokers even a very little produces nausea and suppression of heart action. This shows its *tendency* on all persons.

The empyreumatic seems to be almost negative in its effects, but it gives to the tobacco-smoke its peculiar taste; and it is this substance that makes the clothing and breath of confirmed smokers so unpleasant. *Nicotine* is not necessarily imbibed, by the temperate and cleanly smoker; it is taken and affects only those who smoke "*the whole*" of a Spanish or Havana cigar,

and those who smoke strong tobacco, with dirty pipes, saturated with the oily matters. The effects of nicotine when absorbed are very injurious; it causes a sinking at the pit of the stomach, palpitation of the heart, and sometimes tremor and irregular actions of the heart; tremor and unsteadiness of the muscles generally, and great general prostration; but it does not cause nausea or vomiting. It is the bitter extract of tobacco, when it is swallowed or absorbed, that causes the nausea and vomiting.

*The manner* of smoking produces the greatest difference in effects. Those who smoke two thirds of a Manilla, or who use clean, long pipes of clay, feel only the effects of the gaseous properties and the free carbon. Wooden pipes, and pipes with glass or porcelain stems, are injurious; but cigars smoked *to the last end* are most injurious of all. To be safe, a good cigar should be cast aside as soon as it is half smoked. Leaf tobacco, with a "*long clay*" pipe, is the most simple and safe sort of smoking. The next most wholesome pipe is the celebrated *meerschaum* bowl, with an amber mouth-piece, and *a clay porous stem* that is adjustable. This latter should be often replaced by a new one. The effects of moderate and immoderate smoking on the organs of the body are as follows: —

In the adult man, who is tolerant of tobacco, moderate smoking, i. e., to the extent of one to three clean pipes of the milder forms of tobacco in the twenty-four hours, usually does no great good or harm. It somewhat stops waste in the laborious, and soothes the nervous system; *but there are times* when it is liable to unsettle digestion. To an immoderate degree, i. e., four to six or eight cigars or pipes a day, especially if strong tobacco or fine pipes be used, then *smoking is unquestionably very injurious to the functions and for the health generally.* The blood is made too fluid, the bile is arrested, the digestion is constantly deranged, and there is subsequent dryness of the mouth, and sometimes a nausea. On the heart the symptoms are still more marked; there are palpitation, a sensation as if the heart were rising upwards, a feeling of breathlessness, and, in bad cases, of pain in the heart and chest, which sometimes extends down the arms.

*In most hard smokers* — and two cigars may be as much for one man as ten are for another — the pupils of the eyes are dilated,

owing to the absorption of nicotine, and the vision is impaired; but the symptom most significant is, the retention of images on the retina after the eye is withdrawn from them. Thus, if he turns his eyes from the window after looking there for a minute, he retains the impression of the window, the panes seeming red and the sash dark. When such pictures are thus seen for some minutes after, that smoker may be assured that he has already carried his indulgence beyond the pale of safety.

On the sense of hearing, inveterate smoking produces disturbances; a restless roaring, ringing, or buzzing in the ears, and a sensation as if something foreign was inside the head. The circulation in the brain is also disturbed; sometimes badly, so that there are giddiness, vertigo, and pallor of countenance. The muscles, after much smoking, are more relaxed and less strong. Smoking produces sponginess or congestion of the gums, and tartar on the teeth, and also bronchitis, or *smoker's sore throat.*

To sum up, we find that the grand effect of tobacco on the organization, as a whole, is, to arrest the process of growth and repair. *To the whole body of the growing youth, therefore, the habit of smoking is decidedly deleterious.* Second, a general deficiency or diminishing of power is induced. When, however, the body has ceased to grow, this effect is less; and on the contrary, when the body begins to fall into decay, moderate smoking seems rather conservative. There are numerous instances of extreme old age with great smokers. Moderate smoking for hard-working old people might be an advantage as well as a luxury.

It is said that tobacco dulls and destroys the mental faculties. The facts are, that when the body is in full vigor, the effects of moderate smoking are repelled by the vital powers, while strong smoking does lessen the power of the faculties; but, on the other hand, when the body is overworked and worn, tobacco soothes and conserves. Smoking does decided mischief in cases of bronchitis, and in the consumptive inclined. In the main, tobacco, by either smoking or chewing, is a luxury which any man is better without. But if it is indulged in, the *quality*, the *manner*, and the *amount*, should be so *restricted* that the vital forces shall in every instance *preponderate;* and so not only repel the poison, but turn it to good account.

What are the usual *ultimate* effects of tobacco, by smoking or chewing, on sedentary or in-doors men — such as merchants, manufacturers, clerks, book-keepers, printers, and professional men in offices? From the sum total, the results are various, according to temperament, idiosyncrasy, and the amount of out-door time and exercise, as well as to the quality, method, and quantity of tobacco used. But the most usual results of ordinary smoking or chewing appear to be, sooner or later, a disturbance at the pit of the stomach, and of the head and heart, recurring more severely at times, together with impaired appetite, impaired digestion, relaxation of the skin and muscular fibre, pallid or swarthy complexion, diminished energy, soft or irregular pulse, and a generally diminished power of endurance.

Tobacco may be even *very abstemiously* indulged in by some persons, and yet quite sufficient to produce threatening symptoms, if there is or has long been close business or mental application; or too often or too prolonged enervating indulgences; or if spirituous liquors are also taken, *even in very small quantities, if often repeated.* The coöperation of two or more such causes has too often presented to us the deplorable but inevitable spectacle of *premature old age*, with nervous dyspepsia, hypochondriacal symptoms, head symptoms, heart symptoms, shaking palsy, partial palsy, general nervous debility, sleeplessness, a general inefficiency, with an equal unrest and unhappiness.

Very few persons can continue to consume daily any considerable amount of tobacco, either by smoking or chewing, without the vision, the memory, the heart, the stomach, and the *testes*, one or all, becoming impaired. The fumes and the juice of tobacco appear to act on the brain, the cerebellum, and especially on the origin of the optic nerves; thus producing passive chronic congestion, not very intense, but persistent and very obstinate. Dr. Sichel, in a recent number of the *Annales d' Oculistique*, shows that partial amaurosis is frequently produced by tobacco-smoking. There are many smokers, he says, who may resist these effects for a long time; and the same can be said of other narcotics; the pernicious consequences, however, though slow in manifesting themselves, are none the less real and certain.

# CHAPTER XII.

## USES OF ELECTRICITY IN SURGERY.

### *Swellings and Chronic Diseases of Joints.*

*Indolent swellings*, mostly in or about the *joints*, have often come under our observation, and treatment by electricity, sometimes aided by other means. "*White swellings*," and various tumefactions, — hypertrophic, rheumatic, scrofulous, or dropsical, — succumb to its influence. But to be uniformly successful, we must select the cases. Where such swellings are pale, cool, or white, though tender or hyperæsthetic, I at once attempt the passing of electricity through them; but where there are heat and redness, with pain and tenderness, I do *not* so attempt it, until this character is changed.

*Treatment.* — Electricity, galvanic or faradaic, acts here, probably, first as a *peculiar* stimulus; and second, as an alterative or chemical agent, first by electrolysis and then by catalysis; thus hastening the disintegrating processes, and then the absorption or depuration of exuded fibrine, and other secretions and deposits, and so favoring and aiding resolution. To this end electricity should be caused to pass through such swellings or joints for some little time, in a steady current, very gentle or more powerful, according to the case. It should never produce pain or distress while working: by this I do not mean the prickling, burning, or surface-smarting sensation, for this must be expected in some cases. If it produces more pain, which only *follows* the application, it should not be repeated or continued, until a more appropriate treatment, thus surely indicated by this action of electricity, has prepared the system, and the joint or swelling for this radical treatment.

Large sponge electrodes should be employed for joint affections, except now and then, just at the close of the seance, when

one may be replaced by the *wire brush*, or a metallic tip, for faradaization for a few seconds, or a minute or so, above, below, and over the tumor or joint. But what I value most, besides the direct passage of the current through the joint, is *electrifying the muscles above*, by bathing them with electricity through the large sponge electrodes, in double-circle movements, so as to exercise them lively for a minute or so, just at the close of the seance. If such a joint bears all this well, without immediate or after pain or stiffness, but is rather more comfortable, and more supple, then, after a few such sittings, also try *shocks* through the joint. This is accomplished with any form of electricity, simply by unscrewing the end of one conductor from the machine, and placing the large sponge electrodes on the sides of the joint, with the machine at fullest power; then *touching* the wire repeatedly to the screw where it is usually fastened. Or it may be done by the current-changer, or by the current-break; and still more disturbing and profound effect is produced by reversing the current at each shock. This should be followed by strong handling of all the muscles above and below the sick joint, and with passive movements. But recollect that this is suitable for only the colder, anæmic, insensible, and the more unimpressible cases.

But what shall be done for the *hot* lame joints and tumors, such as cannot receive the electric treatment? *Rest* is with me the *primary* prescription for all chronic, as well as acute inflammations of large joints. In real hip-joint disease, in shoulder, knee, wrist, elbow or ankle stiffening, which heat or electricity makes worse, *rest* must be enjoined, and actually obtained, if necessary, by means of splint. Wherever synovitis exists, only the milder of counter-irritants are admissible, as *formula* 13, 14, or 15. I have often found the day and night alternate application of 34 and 35 an excellent plan; even succeeding in obliterating the sub-acute inflammation, where iodine and all other means have failed. Where the part will bear it, *formula* 8 is a powerful alterative. But I must warn you that all severe counter-irritations, as friction, movements, tincture of iodine fortis, blisters, &c., are to be avoided. So, on the other hand, are we to *avoid* poulticing, or any sort of moist warmth long

applied over any chronic inflammation in or about a joint. Dry heat, that is hot enough to stimulate the flesh smartly, from time to time, is valuable; (else resort to ice treatment, which see;) and after a while begin gentle handling, first of the muscles above and below, and then the joint; and finally electricity, deep-shampooing, movements, and the more stimulating liniments can be used, and thus we may speedily cure a large proportion of such cases.

But suppose the case, from neglect, bad treatment, or what not, is already painful, and the *rest* is not improving it; but rather the patient wastes, and the pains become more and more severe, so that we have reason to begin to fear that the bone structure underlying the joint surface is diseased. We have two strong remedies. One is internal, the other is external; the first is *formulæ* 12 and 7, taken once a day each; the other is the galvanic cauterizer, or the *firing-iron*. Put the patient (or the *little* patient) fully under the influence of ether, and with the iron at white heat, promptly but slowly draw a bold line on the skin, from the trochanter major backwards for four or five inches. This will stop the pain as suddenly and more effectually, that is, radically, than the hypodermic injection. After a time it may, or may not, have to be repeated. If the pain recurs, it must be stopped; for it is believed that this symptom is referable to muscular spasm, which produces articular pressure, and that the disease of the joint is thus kept up. The sudden subdual of all painful symptoms shows that this cautery by heat is a Samson remedy. It instantly dispels the spasm, and its consequences; at least for a time, during which the general health improves rapidly, and the local malady has a fair chance for recovery.

*Joint diseases* have usually three stages, viz.: —

1. The stage of inflammatory and granulating process.
2. The stage of cartilaginous and osseous inflammation.
3. The stage of consolidating and degenerative processes, separately or together. It is only in the cool negative stages of these affections, let me repeat, that electricity is admissible, or can be remedial. When the joint has become quiescent, and there is no longer pain or pressure lengthwise, or otherwise, then

passive motions, electricity, (galvanic or faradaic, or both,) together with deep-shampooing, so as to affect the deeper parts, become very useful. But these means are *contra*-indicated by an active condition of the swelling, as shown by pain or tenderness; or where there is much degeneration or suppuration still going on; or where there are *starting pains*, or exquisite tenderness of the joint surface.

*Chronic strûmous synovitis*, or that form of it where there is a peculiar thickening of the synovial membrane, by a gelatinous, soft, pulpy material, sometimes largely developed, are suitable cases for the electric seance; but not in those cases where pus is produced in abundance. Thus we aid the newly-formed granulations to pass on, as in a healthy subject, into fibrous or imperfect areolar tissues. But in bad cases, this condition will continue, and never advance beyond this first crude condition; the cartilages and bones ultimately become involved, and the case may serve as a typical example of the "*white swelling*" in its bad form. This last stage of the disease we must avoid, as we would the earlier sub-acute or congested stage. To anticipate the final stage must be the object of a well-timed and skilfully chosen treatment.

*Strumous osteitis* must be distinguished from strumous synovitis. Where the bones are thus inflamed, the most important thing is to place the limb in a *good* position, as for anchylosis. Tenotomy may be necessary, not only to relieve the contracted limb, but for relieving the *starting pains*. Rest, time, and constitutional treatment, must here be relied upon. There is a chronic rheumatic osteitis, also, that electricity cannot help. I only mention it that it may be avoided.

*Chronic rheumatic synovitis* may be known from the *strumous* by the great tendency of the newly-formed granulations in and about the joints of the latter to become organized; so that the synovial membrane is transformed into a tough, firm tissue, and anchylosis partial, usually, is produced by new, broad growths of bone. This is quite different from that occurring in scrofula cases, where the bones seem to settle together, one fitting into the other. These, also, must be treated by electricity; and better

too soon than too late, as they are curable only in the rarest instances. Such cases are prone to go lame all their days; without pain if moderate in exercise, but with pain and increased stiffness in proportion to their labor.

*Syphilitic and gouty synovitis, and gonorrhœal-rheumatic joints* are cases curable, by constitutional and electric treatment, as directed in the beginning of this sub-chapter on joint diseases.

*Joints.* — In this connection, we must be guided by Dr. J. Hilton's axiom, "*The same trunks of nerves whose branches supply the groups of muscles that move a given joint, furnish also a distribution of nerves to the skin over those muscles and their insertions, and the interior of the joint receives its nerves from the same source.*" Thus we see, at a glance, how it is we can produce a radical alterative effect in a sick joint, by transmitting a given current of electricity through it transversely and obliquely, according to rule in such cases, and at the same time or seance, faradaizing the skin, fascia, muscles, and nerves *above* the joint, or even by thus operating on the nerves and muscles alone.

The first question for the medical attendant to ask himself, in these cases, is, "*Is the joint actively inflamed?*" This is a paramount question, so far as the use of electricity is concerned. As a general rule, an inflamed joint is bent, partly flexed and fixed; but this is not invariably so; nor are all bent and fixed joints inflamed. For instance, an inflamed wrist is not bent; the joints of the thumb are not much bent, nor are those of the fore finger, for the *extensor indicis* muscles counterbalance its flexor, as in no other finger. But, as Dr. Hilton says, "who ever saw inflamed finger joints that were not more or less flexed? or a hip joint, or a knee, or an elbow?" Even the ankle joint, after a while, shows a raised heel by a shortened *gastrocnemius*, and the toes point downwards. The reflected irritation from the joint to the extensor and flexor muscles causes them to shorten, and the flexors the most, because they are stronger than their antagonists, the extensors. To avoid *gradual flexion and contraction* is to be our first main work; and to this end it is best, except perhaps with the knee joint, to straighten the limb at once promptly, as it is thus most comfortable and favorable for the

protracted rest, requisite for an inflammation to die out in such a site. All active inflammations of joints should be treated by rest, and a given degree of fixity and support, whatever the other treatment be, to insure or hasten the restoration.

The anatomical arrangement of joints, physiologically considered and rightly interpreted, is the means of understanding some of the most important symptoms of joint diseases, as well as pointing to the right methods for treatment. For example, you see the *circumflex* nerve branching into the teres minor muscle and the deltoid muscle, distributing itself also to the skin exactly over the deltoid, and then proceeding to the skin over the fascia of the upper arm, to which the deltoid muscle is partly fixed. The *sub-scapular* nerve trunk, too, sends nerve filaments to this joint, which itself is derived from almost precisely the same part of the axillary plexus as the circumflex; and you may also notice the *articular* branch of the circumflex — the branch which proceeds to the shoulder joint. So, in like manner, you may trace the *supra-scapular* nerve to this joint; for, after supplying the supra-spinatus and infra-spinatus muscles, it sends filaments quite to the interior of the shoulder joint. Thus the same *circumflex* nerve supplies these muscles, the joint which these muscles move, the skin over the said muscles, as also the skin over the fascia, which is a part of the insertion of the deltoid muscle. How wonderful this law of distribution of compound nerves, to skin, fascia, muscle, and joint, just as far as required in their physiological harmony, but no farther!

It is now known that every fascia of the body must be considered, partly, as the insertion of some muscle. Now, we are able to trace the nerves supplying the given muscle, as radiating into a wide extent of the connecting fascia, and that in exact ratio to the proportionate attachment of the muscle to the fascia. Such a precise distribution of nerves to the muscles and articular structures of every joint, forms an accurate association for telegraphing, while in health, mechanical and physiological consent between the external muscular moving force and the vital endurance of the parts moved; thus securing a balance between force, friction, pressure, strain, and deterioration; and when out of health, capable of receiving and transmitting electric influence as a

remedial power, otherwise inaccessible and unattainable. For the above law for health and safety of the joint is often liable to be outraged; the joint is overtaxed, and there result pain, dryness, swelling, inflammation, contraction, or weakness; and now, through this same family of nerves, we are enabled to alter the nutrition, to alter the heat and circulation, and to re-vitalize the deep, bony, and cartilaginous tissues, as well as the sympathizing muscles. But where there are heat, redness, and tenderness, inflammation, acute or sub-acute, necrosis or other disease of bone, or any malignant disease, electricity is not to be used, in any form. After severe and protracted inflammation in a joint, especially where it is allowed to be in malposition, there is very little prospect that any treatment will ever completely restore it; still it may be rendered less painful, and the limb more natural, and greatly strengthened, by suitable treatment.

*Sprained Wrist.* — An injured, and chronically painful and lame wrist is not always a simple sprain. This is as true also of the ankle, and of other joints, as it is of the wrist. These cases frequently occur, and present for electric treatment; or coming with their physician, or without, for advice as to the best method of applying electricity for such a case to cure it. Sprains are usually curable; but some of the intractable cases are rather the result of fracture near the joint, or of both fracture and luxation which have been overlooked. These cases are quite incurable, often, whatever method may be pursued. To illustrate, the following is a common example: —

*Case of Mrs. B.* — Some forty-five years of age; while in feeble health, fell headlong down stone steps, and to save her face and head, received the force of the blow on the left hand. A surgeon was immediately sent for, who, supposing the wrist simply sprained, — for it was rapidly swelling, and painful, — advised a bandage over a compress, wet in arnica, and she was ordered to use or exercise her fingers a little every day, to keep them from becoming stiff. But, at the end of two months, the wrist and hand were extremely painful, and red appearing, the fingers half closed and almost immovable. While in this plight, being completely worn down from suffering and the loss of sleep, her carriage brought her and her surgeon to my door. All this story

was told, and then the sick hand was uncovered for my inspection, advice, or treatment.

At a glance I saw that it was not a sprain only, but an unreduced transverse fracture of the lower end of the radius, within perhaps an inch or so of its articulation. The wrist was stout and stiff, and very much thickened through from palmar to dorsal side; the whole wrist, hand, and fingers appeared of a smooth, shining red, and most exquisitely tender to the touch. The lower ends of the short carpal fragments, as also the carpus and metacarpus, were inclined unusually backward, while the lower end of the long portion of the radius was misplaced forward, thus giving the wrist a thick look, as thick through as broad, while her other wrist was very thin, broad, and flat, being minus of flesh. Surely electricity must fail to restore this ruined joint. It may — it did in this case — lull the pain, and give some strength, and after a long time the hand was considerably improved. But be on the lookout for these cases, and prognose cautiously, for they never entirely recover. The fingers will always remain more or less stiff, semi-flexed, and tender.

### *Wounded Nerves.*

*Diagnosis of Nerve Injury.* — Where a nerve has been *severed*, as by a rifle ball, the muscles to which it is distributed undergo one or more of the following changes, corroborated in the late excellent Report of the United States Army Hospital by Drs. Mitchell, Morehouse, and Keen: —

"There are paralysis of voluntary motion; loss of electro-muscular contractility; loss of electro-muscular sensibility; atrophy, and possibly muscle contraction. The loss of volitional control is instantaneous. The loss of plumpness and firmness, or tone, comes next; and within a few days the electro-muscular contractility begins to fade. Of course, in this total paralysis, the muscular sensibility is extinguished with all the other forms of feeling. Now, let us suppose months to have passed, and that the nerve has undergone partial restoration. We faradaize the limb daily, or every other day. Some of the muscles make no

response in any way; their neural connections are not *re*-made. Others, after a time, begin to fill up; tone returns; the vessels enlarge; the skin flushes; and at last electric contractility and sensibility come back, by small degrees to some, and rapidly and fully to others. These muscles we shall cure in time. If the limb now begins to suffer from neuralgia, it is also a favorable sign; but it may call for a temporary suspension of the electric treatment. In many muscles, voluntary motion is recovered without the slightest exhibition of electro-muscular contractility. Nevertheless, the electricity seems to be working equally as efficient in these as in other cases. In every such instance the use of the battery must be prolonged for months after the return of partial voluntary control.

"Let us again suppose that we have to deal with a case where there has been a *partial* lesion of a nerve, of recent date — a week old, for example. The effect of the local commotion still remains, and some of the nerves have been torn. We here faradaize the muscles in turn. And let us suppose the case to be a wound of the brachial plexus. We find loss of electro-muscular contractility in the biceps, coraco-brachialis, brachialis anticus, and deltoid muscles; with a like affection of the extensor and supinator mass of the fore-arm, with distinct loss of electro-muscular sensibility. The other muscles are paralyzed to the will, but have perfect electro-muscular sensibility, and little or no disturbance of electric contractility. We should conclude that the exterior and posterior cords of the plexus had been severely injured, and the other parts slightly affected. We should also state, as a prognosis, speedy recovery of all the muscles, except those in the range of the circumflex, musculo-cutaneous, and musculo-spiral nerves. One of the branches of the median, which springs from the outer cord, may have escaped injury of any grave nature, although the other nerve of like origin — the musculo-cutaneous — may have been damaged. The muscles which exhibit no lesion of electric properties within two or three weeks after the wounding, we may look to see revive as the effects of the commotion pass away. Those which have lost all electric properties will be least likely to get well, and those in which only the electric contractility is weakened, or lost, will have a chance

of cure, good in proportion to the amount of this property which remains. So that if at the close of some months a muscle has lost all its electric properties, it will be difficult of restoration ; but if the sensibility be not entirely lost, the case is more hopeful, provided the remaining sensibility is not exalted or hyperæsthetic.

"At the close of two or three months it is usually still more easy, in these cases, to make a diagnosis or prognosis. By that time the immediate and temporary influence of shock is at an end. All the muscles, the nerve supply of which was not seriously compromised, will be well, and the examination of the truly involved muscles, by means of the battery, should enable us to say what chance there is of early relief, and what muscles may never recover, or, at least, be difficult to revive. But the whole question will not have been answered until, *at long intervals*, continued and persevering faradaizations have been resorted to; for in these intervals new nerve repairs may have been made, which would enable us to recall to functional life muscles which a year ago, to appearance, were hopelessly isolated from their centres. Under the use of induced currents, the atrophies of the muscles disappear, and the local nutrition receives a singular stimulation. Moreover, simple paralysis may be present, the nerve lesion may have healed, and the muscles, long disused, be merely waiting for some potent stimulus to recall their volitional activity. If the physician cannot tell that this is or is not their condition, they may lie dead, as to motion, for years or for life; and it is here that electric diagnosis becomes invaluable."

*Injury of Nerves.* — The valuable report just referred to, on "*injuries of nerves from gunshot wounds*," was made in 1864, by S. W. Mitchell, M. D., George R. Morehouse, M. D., and W. M. Keen, M. D., acting assistant surgeons U. S. A., in charge of wards set apart by government authorities for the treatment of "*diseases of the nervous system*," in the Army Hospital, Philadelphia ; from which we gather some most important practical points. The author would advise the perusal of this able report by all army surgeons who may not have seen it. The various modes in which nerves are injured are thus classified : —

*a. Wounds* of nerve-trunk, producing partial or complete division.

*b. Commotion*, from the very near passage of the missile to the nerve.

*c. Contusion* of a nerve, as from a blow.

*d. Injury* of a nerve from cold, or sudden chill after heat and fatigue; or from rheumatic deposit in its theca, or from bony pressure, or by stretching or compressing, such as results from strain, or dislocation of a joint, or from attempts for its reduction.

*e. Cicatrix pressure*, the sequel of the healing of a wound that had produced division of muscle fibre, fascia, or tendon, in proximity to a nerve cord. Such a case may be recognized from the fact that no difficulty appears until the wound is well nigh healed, or is quite healed, and recovery supposed certain, when there commence in the limb, or parts below the wounds, an *increasing* numbness, prickling, cramp, and pain in extending the limb, or palsy.

To illustrate this, the case of Lieutenant M., of Cambridge, wounded at the battle of Antietam, is a good example. This young officer was sent to me by Dr. Samuel Cabot, of Boston, to receive electric treatment for the resulting reflex palsy of his left hand, (which, however, might have been, in part, due to the use of crutches,) and for numbness and cramps, and for tonic and spasmodic contractions in the left thigh and leg. It seems that while kneeling, with his men, behind a fence, in close skirmish with the enemy, at the above-named battle, he was struck by a rifle ball or buck shot, which entered the glutei some six inches below the crest of the ilium, passing under the ischiatic notch, grazing or passing very near to the great sciatic nerve, escaping the scrotum, penetrated the opposite thigh, and made its second exit on the outside of the right thigh, about half way from pelvis to knee. He was quite helpless at first, and consequently lay for hours where shot and shell passed over him from both the contending armies. There was not much hemorrhage; and as soon as possible he had a furlough to come home, until the wounds should heal.

I saw him first some three months after the injury. The wounds had healed rapidly and kindly while under the care of Dr. Cabot, but the palsy of the hand and arm rather increased than diminished; and though the wound was quite healed, yet

he was growing more and more lame, with increasing pain on attempting to straighten the limb; and there were numbness, coldness, cramps, and sleeplessness. Indeed, he was inclined to keep the limb well flexed, in order to avoid the insufferable distress.

*Treatment.* — For the paralysis of hand and arm I used faradaization, first by metal electrodes for the first few sittings, under a high-tension current, until the skin received so much sensibility that it became too painful; then the muscles were exercised into good active play by means of moist-sponge electrodes. A portion of eighteen sittings restored this part. For the thigh and stiff knee I instituted passive movements and shampooing by strong hands, for a half hour at a time, which were to be repeated three times a day; with faradaization by large sponge electrodes once a day, or every other day. As a part of the electric treatment, I finished each seance by placing the negative sponge electrode inside his stocking, so as to rest on the top of his foot, while with the positive sponge placed first at the coccyx, it was made to glide over hip muscles, then the thigh, and so on down the leg over the extensors of the toes — in all some three to five minutes. By this means I changed the polarity of the great nerve and its dependencies, and helped greatly to allay nervous irritability, and to reëstablish the natural nervous telegraph of the limb. His recovery, after six months, was almost complete. He is in the army again, serving as a cavalry officer, promoted for bravery and other meritorious services.*

*f. Propagation of inflammatory and other morbid processes along the nerves*, from the site of the original wound of a nerve, or commotion, contusion, or injury of nerve, to the distant plexus, nerve trunk, or branches and their dependencies, involving skin, muscle, fascia, or joint in change of nutriment; resulting in hyperæsthesia, or neuralgia, rheumatism, contractions, anchylosis, pains, pus, or the distressing sensation of burning.

*Joints*, and other parts, — as along the track of inflamed nerve trunks, and over plexuses, where tender under pressure, — if

* *January*, 1866. This gallant young officer returned to the army of the Potomac, was promoted to a captaincy in the cavalry service, and was finally killed in battle while leading his men in the last great struggle before Petersburg, when Richmond fell, and Lee surrendered to General Grant.

thus secondarily affected by a morbid inflammation, spreading or extending from a distant site of nerve injury, should be promptly treated, on the earliest appearance of it, by absolute quiet and a certain fixed position, together with opiates, and a more or less thorough antiphlogistic *régime*. Successions of leeches and blisters are to be followed up until pain and tenderness are quite lost; which is to be patiently carried out, aided, if necessary, by mercury and salines; for it takes a much longer time to quell inflammation in the theca of a nerve, or that propagated into a joint, *from this source*, than ordinary inflammation of cartilage, muscle, or tendon. When thus subdued, electricity, prudently introduced, aided with iodide of potassium, quinine, or iron, can reëstablish the vital properties and the physical capabilities in such damaged parts, so late threatened with a worse condition than death.

*Contusion* of a nerve from a blow is the form of neural injury most frequently occurring in general practice. Though rarely grave in its first effects, it is very apt to be serious and permanent in its results, if not timely diagnosed and correctly treated. (See article "*Joints*.") In fact, a severe blow on a nerve, if neglected, is prone to give rise to ultimate consequences as fatal to functions depending upon that nerve, and sometimes involving others also, as those wounds with destruction of nerve cords, that never can be repaired.

*Perversion of local Feeling and Sensations.* — These may be numberless in kind, and in combinations — the results of brain disease, of spinal disease, spinal injuries, injuries of nerve trunks, and from reflex action arising from functional derangement, as of the stomach, uterus, or urethra. But the most annoying of these, excepting actual pain, are the sensation of *burning*, and the sensation of *numbness*. This latter, when "*a death-like feeling*," is not a defective sensation, nor is it necessarily connected with that condition; for by the anæsthesiometer, we often find, in these cases, the sensation of touch, and the power of localization of touch, perfectly correct; while in other, similar cases, there is partial or complete anæsthesia. Thus numbness may be truly *organic*, or occur as a simple, uncomplicated functional sensation. There may also occur local sensations of insufferable *cold*

or *heat*, where the part is neither actually hot nor cold, but is of natural temperature. There may be formicans, or the sensation of *crawling insects*, even where nothing touches the skin. About the head, down the back, and in the body, may occur a great variety of "strange feelings." Nerve injury, or nerve irritation, is the mother of them all. As to touch and pain, whether they are telegraphed by the same nerve fibres, or proceed from precisely the same nerve centre, is as yet undetermined; but we do know, that one may be taken and the other left. That is, there may be tactile sensibility in a part where there is no susceptibility to pain, as by pricking, pinching, or the cautery; and there may be capability of pain where there is no sensibility, but complete anæsthesia. And where all sorts of sensibility are lost, so that tactile sense, pain, and muscular consciousness are totally absent, and cannot be aroused by the most intense faradaization through the wire brush, still there can be realized the sensation or suffering of a reflex contraction or cramp, that is thus produced, but which shows itself and is felt only in some other part than that touched by the electrodes. Such is the character of a *referred* sensation.

*Skin alteration, and altered condition of other parts from malnutrition*, caused by an injury in the supplying nerve. — These singular cases are scarcely mentioned by authors, yet are of quite frequent occurrence in practice. As the result of gunshot wounds, Dr. Mitchell reports that out of fifty cases of nerve lesions, there were nineteen cases of these results. Two distinct varieties are observable, and both of them are distinct from bedsores which attend spinal disease, for these latter are partly brought on by pressure upon parts mal-nourished.

The first variety is the milder form, although it results from entire division of the nerve trunk, which is not repaired. There is, of course, a total palsy of the limb, with œdema, the skin becoming thick, rough, and dry, partly owing to disease, but mostly from loss of nerve influence.

The second variety is the graver form, and arises rather from nerve injury, and not from nerve division. The first variety results, then, from total loss of nerves; this latter from morbid

nerve action, or mal-nutrition. M. Paget* thus describes this second variety: "*Glossy fingers* appear to be a sign of peculiarly impaired nutrition and circulation, due to injury of the nerves. They are not observed in all cases of injured nerves, and I cannot tell what are the peculiar conditions of the cases in which they are found; but they are a very notable sign, and are always associated, I think, with distressing and hardly manageable pains, and disability. In well-marked cases, the fingers which may be affected (for this appearance may be confined to one or two of them) are usually tapering, smooth, hairless, almost void of wrinkles, glossy, pink or ruddy, and blotched as if with permanent chilblains. They are commonly also very painful, especially on motion, and pain often extends from them up the arm. In most of the cases this condition is attended with distinct neuralgia, both in the fingers and the whole arm. I have seen these conditions of the fingers well marked, and only very slowly subsiding; seemingly unaided by the ordinary treatments of neuralgia."

*Glossy skin, with burning pain*, the result of nerve injury.† — "The skin affected in these cases was deep red, or mottled, or red and pale in patches. The epithelium appeared to have been partially lost, so that the cutis was exposed in places. Where the palm alone was involved, it seemed to be depressed, and firmer than common. In the fingers there were often cracks in the altered skin, and the integuments seemed tightly drawn over the subjacent tissues. The surface of all the affected parts was glossy and shining, as though they had been varnished. No definite time can be named as the period at which these changes in nutrition first show. This alone can be said — they do not belong to cases of complete destruction of the nerves. They occur, with the peculiar burning pain, in such cases as have received slight or severe nerve wounds, provided that these latter do not separate the part entirely from its nerve centre. They may begin within a few days, or at any later date, but usually show first while the wound is healing, and in many instances

* Medical Times and Gazette, London, March, 1864.
† U. S. Hospital Report, by Dr. Mitchell, 1864.

where inflammatory accidents occur in or about the wound. It may last only a few weeks, or for many months.

"We have seen numbers of men, from traumatic nerve injuries, where there was burning pain without glossy skin, and others where the skin was glossy, but unattended with burning pain. When these both exist, the burning comes first, and the skin-change afterwards; but in no case of great change in the nutrient condition of the skin have we failed to meet with this burning pain, and that in its forms of almost unendurable anguish. The language here used may seem strong to those who have not encountered these cases; but no one who has seen them will think, as regards some of them, it would be possible to overstate their most wretched condition."

"*Eczema* is a very constant feature of this state of skin, the result of nerve injury. It appears as minute vesicles, thickly scattered over the thin and tender cutis, or else appears in successive crops of larger vesicles on the skin about the altered parts. In some patients this symptom was absent, in others it was always present, but varied in amount; while in a small number it came and went, being absent for weeks at a time, and then returning. When the eczema came back, the burning and other pains declined."

*Muscle alteration*, from nerve injury, is a frequent result. The general order of muscle-change from this cause is, first, a relaxation, which goes on increasing for a time, and subsequently a shortening. The muscle, paralyzed from such a cause, soon begins to show diminution in its nutrition. It loses tone, and relaxes, so that in the handling of it there is found unnatural softness, or flabbiness of the muscular flesh. In many of these cases, soon or late, according to the gravity of the case, the muscle is not only smaller from disease, but actually begins to *waste;* and this goes on indefinitely, or it may be arrested by the natural or aided restoration of its nerve. In this latter case, by a judicious and persevering use of electricity, shampooing, and passive movements, the whole traumatic phenomena may be recovered from. But where not so fortunate, if not arrested, then the atrophy is soon followed by a gradual

shortening of the already wasted muscle, instead of relaxation, producing the double calamity of permanent lameness and deformity.

The wasting may be slight, while the contraction is extreme; or the contraction little or none, where the wasting is great. So that in these respects we may expect to meet great varieties. The bruised or crushed nerve, although it does not produce such prompt or complete paralysis as does a severed nerve, and many other nerve injuries, yet it is the most prone of all to leave, in the end, pains, contractions, atrophy, anchylosis, and other lasting evils.

Whenever a nerve is seriously injured, in any way, we may expect to find *sensation* perverted, exalted, diminished, or destroyed; *muscles* irritable or paralyzed, and the *nutrition* of the muscles and other depending parts damaged. In some cases we may have but one; in others, two; in others, all these *triple* results. In the majority of cases all these occur in the same case, only in varying degree. From this it would also appear that there are three sets of nerve fibres, instead of two, leading from the spinal cord into all the muscles, fascia, and skin of the limbs and surface of the body; but this is not yet proved.

*Muscle shortenings* should be recognized in three different classes, each of which is distinct from the other, and requires entirely different treatment. In the first class we may recognize the atrophic shortening; in the second, idle shortening; in the third, spasm shortening.

*Atrophic muscle shortening*, a contraction which follows true atrophic alterations, must be discriminated as organic, and almost, if not quite, hopeless. When atrophic shortening occurs, and the opposing group of muscles are also paralyzed, the evil is irremediable helplessness and deformity.

*Idle muscle shortenings* are those which occur in consequence of the paralysis of their antagonizing muscles, so that these muscles are consequently idle, besides being poorly nourished. These cases are usually curable by means of electricity, if so applied as to wake up the nerves and exercise the paralyzed muscles, aided by shampooing, stretching, and passive movements, and if perseveringly pursued.

*Spasm muscle-shortenings* are the result of muscle irritability, or tonic spasm; and that is usually caused by lesion of its nerve. We may see a single muscle thrown into a persistent contraction without atrophy. The part is well nourished, and the spasm capable of being overcome, but instantly returning. There is usually some volitional control, and the electro-muscular responses are entire. Sometimes a kind of tremor may occur in the affected muscles, and the spasm or shortening varies so as to show more some days than others. Unlike the two former classes, it relaxes under etherization, and is capable of temporary relief, and in some cases of permanent cure, by injections of *atropine* into the body of the muscle; whereas no effect is thus produced when muscles contracted by other causes are so treated. Dr. Mitchell* says, in his report, that of the three most prominent cases of this sort, two were due to nerve wounds, and one was due to rheumatic paralysis.

"Atrophy may exist alone, or be associated with like conditions of the skin and its appendages. Atrophy of the muscles of an entire member is sure to follow the complete division of its nerves, *when there is no subsequent repair*. In this case the muscles waste alike, the areolar tissue shrinks, the vessels fade from view, and the pulse becomes feeble and small. The rate at which this process goes on varies greatly; but it begins early in extreme cases, and continues until nothing is left but bone and degenerated areolar structures, covered with skin, whose altered surface tells of the singular blight which has fallen upon the member. So complete a destruction is commonly the work of years; but in some nerve wounds, when the main artery has also been destroyed, the atrophy was rapid. Partial atrophy is a much more usual symptom, and gives rise to strange and almost grotesque deformities in the limbs it attacks, as is well shown in the collection of casts which have been deposited in the Army Medical Museum.

"The subsequent tardy repair of the nerve implicated may occur, however, without the affected muscles regaining their size and strength. But if, under such circumstances, electricity be

* Extract from the U. S. Hospital Report, Philadelphia, 1864.

locally applied, as early as consistent, repair is often speedy, and is preceded by certain changes in the electro-muscular manifestations, to be hereafter described. Of this we are distinctly sure — that there is no test of the restoration of nerve supply, except the electric current; and that, without its timely aid, a cure is often hopeless, where the atrophy is well marked, no matter how perfectly the nervous communication may have been restored. In partial atrophy, voluntary power is proportionally diminished; but, on the other hand, there may be, and often is, motor paralysis of a muscle group, without any more wasting than disuse would account for. These cases, too, are curable."

Reunion of divided nerves, and recovery of function, *cannot* be promoted by "*nerve-suture*," as has been so repeatedly tried. The most favorable surgery is, to simply place the two ends of the severed nerve in as close, accurate, and quiet coaptation as possible, and thus await patiently the result of cicatrization, either by first or secondary intention. We must wait months to realize the full results, but in the mean time we may aid the restoring process.

All kinds of nerves have been operated upon with nerve-sutures. It is found, that if a divided nerve is drawn or held together by a suture, plunged through the nerve, near the two cut ends, there is no tendency to healing by first intention. This procedure thwarts it. There is complete evidence of interrupted conduction through the nerve, and lost function of the peripheral portion of the nerve. That is, if a motor nerve is divided, we observe loss of motion and of electric contractility of the muscle; if a sentient nerve is thus treated, there is loss of sensation; if a vaso-motor nerve is severed and so treated, there is increase of temperature, stagnation of blood, change of nutrition, and even gangrene; and all these conditions continue. Microscopical examination shows that the peripheral end has rapidly undergone fatty degeneration, and the central axis partakes in the degeneration, while the central end remains comparatively unchanged.

This operation of tying together the severed ends of a nerve trunk, thus far proves, that it is attended frequently with pains and numbness, a more or less extensive neuritis, or peri-neuritis,

which may even give rise to suppuration and metastatic abscesses in the parenchyma of the lungs. We must, therefore, regard this procedure as unjustifiable.

*Bronchocele* evidently results from a perverted action of the nervous functions. I am sustained in this view by high authority. There must, therefore, be made a profound impression on the nerves in and about the tumor, also a radical change in the constitution, in order to stop the progress of this disease, and to effect a cure. To this end, I *first prepare the case* for active treatment, by prescribing hydrargyri bichloridum, with tincture of bark and quinine, or the biniodide with the iodide of potassium. Then commence the daily, or every other day, smart applications of faradaic electricity, through large and fine sponge electrodes, applied on and about the enlarged gland on the throat, for some five minutes at a time, varying their site every minute, for five or ten minutes. Next, transmit a stronger current, — the primary if at hand, or the *extra*, or else the faradaic, — through and through the enlarged organ, in various directions, in all from ten to fifteen minutes; moisten the electrodes in *formula* 34 every time.

After such treatment, apply citrine ointment, unguentum mercurialis fortis, or ung. iodidi plumbi, and cover with oiled silk, which is to be worn during the intervals. Prescribe the extract of nux vomica or strychnine internally; the latter in $\frac{1}{20}$ or $\frac{1}{30}$ grain doses, once, twice, or three times a day, taken directly after a meal. This treatment must be persisted in for six to ten weeks, and thus it often effects a radical cure.

*Ranula under the Tongue.* — A woman, aged sixty-five, applied to Dr. Scarenzio, an Italian physician, on account of a swelling, situated on the right side of the frenum, which, in three months' time since it first appeared, attained the size of a walnut, causing a difficulty of speech and mastication. There was also some swelling of the sub-maxillary glands of that side; but this had rather diminished as the tumor increased. The affection was, on the whole, considered uncomplicated, and electricity was thought the best thing to bring about a cure. Two pairs of Bunsen's cups were employed, and a steel needle, attached

to the negative pole, was passed about four centimetres into the fluctuating tumor; the positive pole, with a moist sponge, being now brought into contact with the outer surface of the lower jaw. The whole current was thus allowed to act for nearly a quarter of an hour, the patient complaining of only a slight smarting. At the seat of puncture an eschar was formed, and on the removal of the needle a portion of the fluid was discharged, the whole afterwards flowing out during the movements of the mouth. Next day, strong local reaction was set up, accompanied by feverishness, which yielded to antiphlogistics. In a few days the eschar came away; the granulating wound healed, without any further fluid having taken place in the cyst, which contracted upon itself to obliteration. The function of the Whartonian duct was recovered, saliva being seen issuing therefrom. Some fifteen months after the operation the lady was seen, and the cure was found to have held perfectly good.

*Syphilitic Disease of the Larynx.* — By the aid of the laryngoscope, Drs. Czermak, Storck, and Turck have discovered and detailed every form of this manifestation in the larynx and surrounding textures, including various kinds of ulcers, catarrh, condyloma, scars, and the various general and local symptoms attending this affection. Out of fifty-six persons affected by syphilis, eighteen showed the affection in the throat. Out of nineteen men, five; and among thirty-seven women, thirteen were found to have the larynx diseased. Out of forty-four patients with secondary syphilis, there were eleven with laryngeal affection; and out of twelve patients with tertiary symptoms, there were found seven. There are hoarseness, dyspnœa, and pain on pressure outside over the larynx. Even after many years, from primary syphilitic symptoms, the patient may be liable to the chance of having this throat affection. The prognosis depends upon the different degrees of the throat disease, which may vary from a slight catarrh to complete ulceration, or even destruction of the *cordæ vocales*, or of patches of bronchial substance; or else there may be small vegetations of morbid growth.

*Tongue furred on one Side only.* — A few cases of unilateral furred tongue have come under my own observation, which I

ascribed to a nervous origin, being most usually attended with affected teeth in the *upper* jaw of that side. One case was different: Mr. Charles C., of the Mass. 25th, was wounded at the battle of Fredericksburg by a piece of shell striking him just back of the right ear while lying already wounded, fracturing the base of the skull, so that blood flowed from the external *meatus*. His teeth were all sound. I obtained his discharge from the service, and after six or seven months, as he recovered from the shock, and the effects of the wound, the fur on that side of his tongue gradually cleared off. He has quite recovered now, and has a uniformly clean tongue. Recently Dr. John Hilton has reported several such cases, where he found the first or second molar tooth in the upper jaw on that side diseased. He justly remarks, that there is a difficulty in explaining this fact; for instead of the cause being associated with the third division of the fifth pair, as we might expect, from the lingual gustatory nerve supplying that part of the tongue, — the anterior two thirds, — it seems to be associated with the second division of the fifth, but always on the same side. In most persons the state of the mind affects the appearance of the tongue. A perfectly clean tongue may, from bad news, or any worry of the mind, become furred in ten minutes.

### *Nervous Affections of the Eye.*

*For painful eyes* without inflammation, for "*strained eyes*," and for the rheumatic, neuralgic, and other painful states of the eye, when independent of any organic disease, a light, very light, faradaic current gives the most grateful sensation, and is the most uniformly successful and lasting remedy. Among the opera-going, and in fashionable life, these cases are the most numerous. Among these are many cases of neuralgia of the ciliary muscles. The pain is deep within the eyeball. Such patients can see well enough, generally, all things about the room, or in the street; but the moment they begin to read, or write, or sew, or in any way attempt to *fix the focus of the eye* on an object near by, then there is distress that is lasting. They are thus cut off from reading, writing, or being in a bright gas light;

and this state may continue for months, or even years. For the method of treatment, see Rules 8 and 9, on page 465. Prescribe, also, *formulæ* 1, or 2; or 12, 24, or 28, with very plain food, and perfect rest of the eyes, (as from reading or the like,) to keep out in the open air, and to bathe the eyes in warm milk and water, or *formula* 27.

*Blindness* is a common *symptom* in diseases of the nervous centres. In almost all cases of cerebral amaurosis, the ophthalmoscope shows white atrophy of the optic disk. Sometimes, if seen early, the optic disk is observed to be swollen, and the vessels gorged, as if the return of the blood from the eye was impeded. Atrophy of the optic nerve occurs also in persons who appear perfectly well in all respects except diminished sight. It is also found in some epileptics. It is very common to have a series of symptoms preceding this kind of amaurosis — which are, violent pain at the back part of the head, and in the super-ciliary region, with distressing vomiting; and this is the same kind of symptoms so often associated with tumors in the cerebellum, and with which amaurosis is so commonly connected. Several well-authenticated cases are reported of intense pain in the occiput, darting towards the temples, with urgent and frequent vomiting, rigidity of muscles of the back of the neck, and imperfect vision, which the subsequent autopsy proved to be the result of tumors in the middle lobe of the cerebellum.

*Appearance of the Eye.* — An abnormal appearance of the eye may be a result of *former* disease, or it may prove to be a significant sign of existing cerebral disorder. But in estimating the value of any morbid state of vision, or appearance of the eye, we must make allowance for possible local diseases of the organ. We may find strabismus a simple local affection; we also find it a usual occurrence in brain affections. We likewise often find it previous to an attack of apoplexy; in meningitis, in tumors and pressure at the base of the brain, and during convulsions. The pupils are variously affected by cerebral disorders. A dilatation of both pupils is found in all *depressing* effects from compressions of the brain, and especially from collection of fluid in the ventricles, and in the sub-arachnoid spaces. In such cases the retina seems insensible to light, and the pupils

react slowly, and but partially. We also find this double dilatation in chlorosis, in anæmia, in nervous exhaustion, and when the system is under the influence of belladonna, stramonium, or tobacco.

A one-sided contraction, like a one-sided dilatation, of the pupil, is ordinarily the result of a one-sided irritative lesion of the cerebrum or cerebellum; or else it may be owing to tumors on the side or back of the neck. We find a double contraction of the pupils in the earlier stages of cerebral inflammation, and in these cases it is associated with intolerance of light, which does not occur if the contraction of the pupils be produced by narcotism or coma.

*Derangement of the Sense of Vision.* — In disorders of the *brain*, whether functional or organic, the sense of vision may become exalted, impaired, or perverted. If there is inflammation, it is exalted. It is impaired, or even totally lost in softening, tumors, and apoplexy, and during violent hysterical attacks simulating apoplexy. Perversions of the sense of vision are more frequent than its abolition, and probably more peculiar to cerebral affections. Some are of grave significance, such as *double* vision, which, unless connected with strabismus, is almost always the result of cerebral disease. Some persons see but *half* of an object, and this, too, may signify a debility or injury in the brain; or it may be due to some simple local affection of the eye. In the former case there will also be headache, and the mind will show signs of disorder. But the most frequent, and of the least significance, are the movable *muscæ volitantes*, or the delusion of spots, or small objects *floating* before the eyes; for these may occur in almost every slight or grave form of cerebral disturbance; as also in cardiac affections, in anæmia, in the neurosis, and in some states of nervous exhaustion.

*Strabismus.* — The various defects in and about the eye which cause converging squint and double-sightedness, are numerous. Thus strabismus may *originate* in an affection of the eye muscles, either from spasm, or from paralysis; or it may arise from defect in sight, and then the unequal muscular action comes on as the result. The cause may be insufficient refractive power. Here the refractive media are too weak to bring parallel rays to

a focus on the retina without calling to their aid "the power of accommodation." If this latter power is strong, no squint is the result. But if the ciliary muscles are weak, then the morbid symptom appears; because very strong contraction of the internal rectus muscle produces, also, the augmented contraction of the ciliary muscle. Such cases, when early treated by electricity and tonics, are usually curable.

But too frequently this process begins in childhood, while learning to read, and is overlooked, or neglected, until confirmed. The long over-use of the internal rectus causes its hypertrophy, and by and by the *external* rectus cannot antagonize it; and then the internal rectus begins to undergo permanent shortening and partial degeneration. Now, it is not a case for electric treatment, but for surgery by the scissors or knife.

*Strabismus* of another sort — a squint with *diplopia*, or double-sightedness — may be, and most frequently is, caused by a paralysis, more or less complete, of the *external* rectus muscle of the eye. Other muscles of the eye, however, one or more, are sometimes found palsied, or partially so. But when an eye muscle is paralyzed so as to derange the axis of the ball, such an eye is said to be in the state of "*lusciias*." Whether complete or incomplete, the weakened or paralyzed muscle, or muscles, causes a degree of strabismus whenever the eye looks towards the side where the paralysis is, and there the double images will accompany it. Now it is possible, even after long standing, for some such paralyzed eye muscles to recover by the aid of electro-magnetism and tonics, and so cure the deranged eye. But many cases are irremediable, because of the acquired hypertrophy and degeneration of the antagonizor, which must render them permanently unequal.

More weakness of the internal rectus muscle, naturally existing, or brought on from over-taxation, can induce slight alternating or permanent squint of the *diverging* variety. I have had cases that were seemingly brought on from working worsted, fine lace, tatting, and hair-work; and one case from looking much into a stereoscope. Thus the undue taxation of the muscle is followed by still greater weakness, sufficient to allow the eyeball to be pulled more constantly out of its true natural

position. Now, when such eyes are adjusted to any near object, for any little time, as sewing, reading, or writing, *it causes pain in the eyes*, and there is indistinct sight, letters run together, or are double; now the eyes are seen to be more or less diverged, without the patient being aware of it. Now, too, *the pain in the eyes*, and inability to use them, bring them for electric treatment.

*The electric treatment* of the various recent and otherwise suitable cases of strabismus, with or without complication, must be varied for the given case. If it is the result of long overuse, — "*strained eyes*," — and there are sensitiveness, pain, and weakness, the negative sponge must be at the pit of the stomach, while with the positive, the face, temple, and eye region are bathed over with electricity, through a large, fine sponge electrode, the same as for neuralgia. If there is no pain, weakness, or undue sensitiveness, in or about the eyes, then proceed as for palsy of eye muscles, or in cases of simply diminished sight, from loss of tone, by electrifying the eyes and eye muscles. Commence with a low faradaic current, and holding a sponge electrode in each hand, apply them in front of the ears, and so glide them towards and upwards, and over the eyes, by gentle gliding movements; then back again to remove them. Exchange them in the hands, increase the current, and repeat the application for several times. If there is spasm of any eye muscle, faradaize over and about it smartly, by brushing over the closed eye with the fine wire-brush electrode. This latter will be painful, but it will often cure, in recent cases.

*Opacity of the Cornea.* — Electricity is a most valuable *aid* in the treatment of most of these cases. I have seen it succeed without other aid. Dr. A. von Graefe (now one of the most celebrated oculists in Europe) has given it a fair test in such cases, and his opinion is decidedly in favor of its use. He took for this purpose several patients, in whom both eyes were similarly affected, and treated the one eye by *faradaization*, and the other by *opium*, nitrate of silver, &c. The result was, he says, that "the cure by means of electricity was much more certain and speedy than by any other treatment."

*Treatment.* — My own course has been to employ electricity at the same time, or alternately, with other means, and it has often

been attended with good results; but the treatment must necessarily be protracted, just as any other course pursued would have to be, in order to succeed, in such cases. No accident, no evil consequence, has ever attended it. But I have always observed my own rule, viz., never to treat a complicated case with any quality of electricity, as while the eye shows signs of active inflammation; nor where there is also undue sensitiveness of the skin about the eye to a gentle current; nor where there are neuralgic pains *with tenderness* about the eye, face, and forehead. In most of such cases, as yet, the patient would be more likely to be injured than benefited. But even if there is neuralgia, *if there is also coldness* of the skin, or anæsthesia, or diminished circulation and muscular action, the case should be treated with a gentle current, and tonics, to cure the neuralgia, and then we are to attack the opacity more immediately.

For this purpose, we may use faradaic electricity, or static electricity. The *inducing* current must be of the smallest or weakest possible, so as to merely keep the machine going, to produce a low-tension inductive current. This is done, first, by having a weak battery solution, or by lifting the zinc part way out of the solution; and still further, by mostly withdrawing the bundle of soft-iron wire from within the helix, or employing the *extra* current. The vibrations should be as rapid as such a low current will admit. We are then to choose two fine sponge electrodes, one of which may be of the ordinary size, — say one or two inches in diameter, — while the other sponge is not larger than the tip of the little finger, so as to be readily adjusted over the eyeball. These are to be well moistened with water; the larger one (positive) is to be placed on the side of the face, and so slid along (while the current is running) in front of the ear, or on the temple; while the smaller one (negative) is first to be manipulated over the orbicularis muscle and about the eye; then on the eyeball, with the eyelids closed.

The current may be reversed several times during the seance, to arouse the trifacial nerves; but the prevailing direction should be *towards* the cornea, and as strong as the patient can well bear. If there is a neuralgic tendency, it will not do to change the current direction; but make the whole sittings with the

small (negative) electrode, on the eyeball, or close about it, while the other electrode (positive) is on the temple, or over the front of the ear. If reflex action is desirable, through the optic nerves, one electrode can be placed on each eye, and manipulated there and thereabout, for half a minute, or so, and then reversed, or exchanged; and this may be repeated several times at each seance. The same may be effected, in less degree, by placing one electrode back of the neck. This treatment may be repeated daily, every other day, or twice a week, according to the effect.

When opacity of the cornea is the result of severe and protracted inflammation, the cornea often becomes very thick. In one case, a man from Quincy, who had been blown up, while blasting rocks, his face and eyes filled with small fragments of granite, powder, and brick dust, and where inflammation ran high and long, one year after the accident was sent to me, by Dr. Thaxter, for electricity. The case was treated daily, for a month, according to the foregoing rule, without much effect. We then commenced thoroughly scarifying the cornea of only one eye at a time, but alternately, every week, bathing the eye with dilute laudanum, and continuing the electricity.

It was remarkable how soon these eyes began to improve. The treatment was continued for some five months. During the latter part of the time I employed static electricity at every other seance, *by drawing sparks*, of half an inch to an inch long, from the eyeball; at first from the naked cornea; but, as it recovered its tone and sensitiveness, the eye was allowed to be closed, and the knob of the discharger was held above the eyelid. To accomplish this, the patient must stand or sit near the negative end of the electric machine, so that the discharger can be connected with it, and yet the ball-knob may be adjusted near the eye, while a third person turns the crank; and at the same time the prime conductor is in contact with the earth, or at the back of the neck of the patient, for reflex action. This doubtless facilitated the recovery of this unusually difficult case; and it certainly was a success.

Mr. M. regained quite clear sight — perfect sight out of the

left half of the left eye. It is now several years since this occurrence, and the sight of this man remains very good.

*Amaurosis*, when purely functional, is a nervous affection that properly comes within the scope of appropriateness for the electric treatment. In doubtful cases, we are to resort only to faradaic electricity, of weak currents at first, thus simply electrifying the face and forehead, and the muscles about the eye or eyes, through large sponge electrodes. In fact, this may be repeated from day to day, more and more smartly, if no decidedly bad effects follow; for it is proper treatment so far as it goes, and is perfectly safe, and is often alone successful. This kind of electric operation, on the terminal twigs of the fifth pair of nerves, has a good influence on diminished vision, by a reflex action. But in some cases this brings no improvement to the sight. We are then to resort to the primary current, from 10 or 20, or 30, of Daniell's elements, applied from temple to temple, by large sponge electrodes, and reversed every quarter minute, until flashes of light are distinctly produced. Smaller sponge electrodes may be placed respectively on the eyeballs, (one being held in each hand of the operator,) over the closed eyelids, and then proceed as before, but with less current. This, using a primary current, is probably the most profound mode of electrifying the retina and optic nerves.

Another method in amaurosis is, to place the positive electrode (a large sponge) at the back of the neck, and with the negative apply to, over, or about the eye, as the case may bear and require. Another and milder method, adapted to delicate and doubtful cases, is, to place the negative sponge pole over the solar plexus, while with the positive operate on or about the affected eye. But this latter method is not very efficient in amaurosis, or simply diminished sight; it is just the method for neuralgia of the eyes.

But, wherever we have reason to suppose the *diminished sight* is owing to inflammation or congestion, or any other organic disease in the retina, or about the eye, or brain, of course electricity is not to be employed. But in suitable cases for this, as where there is simply diminished nerve power in the retina and eye generally, I am not limited to this agent alone, but

prescribe the internal use of iodide of potassium, or iron and quinine, or the Asiatic pill, made with the extract of nux vomica; looking well to the state of the stomach and bowels, as well as all the *habits* of the patient. If the case is complicated, still we must push the treatment if we can, but modify it if we must. The longer the blindness, the less prospect of our complete success.

Where the patient "*sees double*" *persistently*, and in fact, as a general *rule*, in all cases of supposed head affection, where the patient sees double, or sees only half of an object at a time, this is to be considered as a very bad symptom, and death may be feared or expected from effusion into the substance of the brain, sooner or later. True, we do meet with many cases in which some shade of this abnormal state of vision is *temporary*, and is then only indicative of some functional derangement; but mark, where it is of longer standing, or other evidence of cerebral mischief impends, it is always a suspicious symptom, and should be closely watched.

The state of the *iris*, in diagnosticating "cerebral lesions," is of importance. We should perhaps look first to the mental condition, but next to the state of the pupils of the eyes. If the eye itself is diseased, the dilated pupil indicates more or less pressure on the retina by some cause within the globe, such as turgid *choroid*. But when the eye is healthy, and the brain has received some supposed injury, we usually find a *dilated* pupil as a sign of some grave pressure or injury to the optic nerves within the skull, or of the ganglia in which they terminate. The *contracted* pupil, on the contrary, indicates an irritability, or inflammatory state of the brain, — an exalted excitement of the natural function, — but not an obliteration of it. "Sometimes," says M. Solly, "we may see, as in the case of injury of the brain, dilatation of one pupil, and contraction of the other; when this is the case, you will find the most severe injury of the brain on the same side with the dilated pupil."

A seamstress came under my care for a blindness that came on very suddenly in one eye, after sewing on black satin by gas light. The pupil was dilated and *immovable;* she was totally unable to distinguish even light from darkness. The case ap-

pearing to be one of idiopathic palsy of the iris, I therefore proceeded at once to apply electro-magnetism, directed to the opposite sides of the naked cornea, by very small ivory and sponge-tipped electrodes, conveying a very weak, but rapidly interrupted current. Three applications restored the sight, and tonic medicines, with rest, confirmed the restoration. There is a nervous affection of the eye, termed *musca volitantes*, which is an aberration of the sense of sight that transmits the image of some of a multitude of imaginary objects. This may be simply symptomatic of *fatigued* nerves, or it may be idiopathic, and connected with the state of the brain. I will concisely say that where the "black spots" or "shining sights" have a circular or *perpendicular movement*, particularly if at winking, the affection is then probably symptomatic, requiring rest and very gentle localized Faradaization by *team-electrodes*, or a bathing of the closed eyes and surroundings with the moist sponge *positive* electrode, while the other is on the back of the neck. If the black spots, &c., are *stationary*, they probably are idiopathic, and should not be so disturbed.

A young gentleman, a student at Cambridge, came to me with blindness of the right eye, which he said was a sudden occurrence, and that, probably, from too close study by candle light. He could still see *very distant* objects quite distinctly; but he could not make out objects near by if his well eye (which was also dim) was closed. The pupil was largely dilated, the iris being drawn closely to the ciliary ligament, and it was unmoved by the approach of a strong light. He had been under the care of one of the most distinguished oculists for the six months previous, during which he had been leeched, blistered, and mercurialized, without any benefit. A weak current of induction was first tried for a few times, directed upon the two sides of the globe of the eye, over and through the closed eyelids. This was without effect. I then made gentle touches to the sides of the cornea and sclerotica, and at the close of each seance applied by a camel's hair brush a weak solution of sulphate of copper around the sides of the cornea, where the electrode had just touched. After ten such sittings,

performed every other day, his eyes quite recovered, now bearing close study, and yet remaining strong.

*Ptosis*, or "falling of the upper eyelid," often arises from an *atonic* or paralytic state of the *levator palpebræ superioris*, owing to some alteration in the nerve that supplies it; or it may arise, on the other hand, from a spasmodic action of the *orbicularis palpebrarum*. When this affection occurs from true local palsy, i. e., showing that the third pair of nerves is palsied, then there is usually "*squinting*" with the ptosis. In this case, we should bear in mind that, usually, electricity in any form is not only useless, but hazardous. In the former, Faradaization of the *palpebra superioris* muscles and its nerve trunk will cure it.

When only the motor portion of the fifth pair of nerves is palsied, then there is usually found, moreover, a slight loss of sensibility in the parts of the face supplied by the *tri-facial, and the motions of the jaws*, on the affected side, are impaired. Mastication is therefore difficult on that side, owing to the palsy of the *masseter* and *temporal* muscles. This may occur alone; but more usually there is also loss of sensibility and palsy of the *portio dura* and the face muscles of that same side.

### *Nervous Affections of the Ear.*

*Hearing.*—An abnormal sense of hearing, whether exalted, perverted, or diminished, may be a *local* derangement, or a disease; or it may be a very significant sign of existing *cerebral* derangement, or disease. The external ear should be carefully and thoroughly explored, as also the condition of the eustachian tube. If physical impediment or imperfection exist, our anxiety may cease. But deafness may be owing to softening of portions of the brain. *Tinnitus aurium*, a metallic tinkling sound, real or imaginary sounds, and ringing, roaring, and fizzing noises in the ear or ears, or head, are frequent accompaniments of cerebral disorders. But we must repeat, that they may also result from simple local obstructions, or a local disease; from congestion of cerebral vessels; from congestion of brain; in affections of the

heart; as also in anæmia; so that they become most critical signs, and can be interpreted better by their history, and surroundings, than by their character.

*Ear-wax* (which in this country is a common term for the natural secretion of the ceruminous glands, in the ear passage) may be found in varying quantity and quality, and yet be healthy, as we find in one person a different degree of perspiration from another; but so long as it is of the normal yellowish color, and of a soft, basilicon consistency, it cannot press upon the drum of the ear. Hence it cannot communicate pressure from the membrana tympani to the ossicula auditus, and thence to the labyrinth, which probably causes the vertigo and impaired hearing in other cases.

Not farther than a line or two from the external orifice of the ear meatus are the ceruminous glands found, which line the passage, and extend inward to the tympanum, secreting "*ear-wax*," sometimes of such thick consistence as to retain its position, and catch the particles of dust, and gather the small hairs, until it fairly clogs the passage, and damages the hearing, and injures the ear. There should be a secretion, but the cerumen should be semi-liquid, like thin honey, and self-clearing by the action of the jaw, or by the use of the finger and towel. Every child should be taught to thoroughly wash and shampoo the ears daily, to keep them in vigorous health.

The violent pain and fever which attend inflammatory attacks of the meatus and outer layer of the membrana tympani, if not promptly reduced by purgation, fomentation, local depletion, and opiates, are apt to be followed by perforation of the drum. A slight discharge, if neglected, is prone to be followed by actual otorrhœa; or the inflammation becomes periosteal, and spreads to neighboring structures, and may prove fatal, or result in deafness. *Bad treatment* may suddenly stop a discharge from the ear, from the now increased inflammation this meddling has brought on, which may soon be followed by very grave symptoms. Therefore beware how you tamper even with an external auditory meatus from which flows a discharge, as there is danger. Dr. Toynbee teaches us to see to it that the patient is not made worse. I would say, emphatically, touch not such an ear with electricity.

If there is a perforation of the tympanum, of large size, the air within the ear does not vibrate as strongly as natural; therefore a plug of moistened wool, peculiarly adjusted, temporarily restores the hearing. If the eustachian tube is inflamed, or is in a catarrhal state, or is enfeebled and collapsed, so that air cannot readily pass in and out of the internal ear, then the air is not equal in density on the two sides of the ear drum, and it is thereby rendered too concave or convex, and there is diminished hearing, and probably noises of a hissing, roaring, or buzzing kind. The tympanum is the dryest membrane in the whole body; but it can be inflamed, and become very red; but this intense redness is more frequently seen to be *around the edge* or insertion of the membrana tympani. The stapes may become ankylosed; and this, doubtless, is a common and irremediable form of deafness, and is probably the result of age, or of the rheumatic diathesis. Hearing, for such cases, cannot be restored by any means now known to the aural art.

*Diminished Hearing, and Noises in the Ear, from Inspissated Cerumen.* — Whenever a new case presents, having ear difficulty, to be electrified for deafness, partial deafness, or for roaring or buzzing noises in the ear, the *meatus auditorius*, *externus*, and *tympanum* should be first carefully inspected, before commencing the electric treatment. There are numerous contrivances for illuminating the auditory canal, which of course do not supersede sunlight, — at least for the practised aural surgeon. The one I employ, however, can be used in all kinds of weather, in any place, or at the bedside, by means of ordinary diffused daylight, or with an artificial light of candle, kerosene, or gas; and it is portable.

My method is, to use a Toynbee or Wild speculum, with a magnifier, and by means of a centrally perforated concave glass mirror, from three to three and a half inches in diameter, of *six-inch focus*, and having a handle. Even if there is afforded but a very limited light, — be it sunlight, daylight, or candle-light, — still a careful and sufficient examination may be made. If not thorough, and perfectly satisfactory, try again, under more favorable circumstances, so as to know, if possible, the exact condition of that part of this crooked canal just in front of the

tympanum, where we wish to rest the sponge tip of the ear electrode.

Besides, partial deafness and noises are thus often found to be caused by a plug, or patch, of blackened cerumen, hiding the membrana tympani from view, which, when removed, becomes of itself a speedy cure, but without the removal of which there can be no cure. These concrete masses I have found in one, and sometimes in both ears, where overlooked, or not suspected, and where I have no doubt it had been a source of difficulty for several years, although treated repeatedly for the noises and diminished hearing. An inspection of the canal will at once determine the condition of things. But before this has been had, nothing should be done by means of electricity.

*Case.* — Miss B. remembers that, about nine years ago, she slept with a window open, as accustomed to do, but on waking found a change of weather, and a sensation as if she had cotton in her ears. Then there came on a buzzing sound, with diminished hearing, which has never ceased. From time to time she has had earache, neuralgia about her head, and sometimes protracted spells of almost total deafness and vertigo, for which she had, in various places, consulted a number of physicians and surgeons. Never had any discharge from her ears, and those who examined them superficially said they were clean and dry. Her hearing distance, when she came to me, was only as close to the ear as the watch could be held and not touch it. Both ears alike. Ocular inspection, with speculum, magnifier, gas-light, and perforated reflector, showed some black obstruction filling up the deep part of the canal. Suspecting it to be hardened ear-wax, the ears were thoroughly syringed with warm water and castile soap, first one ear and then the other, for three quarters of an hour; but no removal of the obstruction could be thus effected. By means of a long camel's-hair brush, I then introduced a saturated mixture of borax and glycerine into each ear, and then wet bits of cotton and plugged them. This was allowed to remain until the next day, although uncomfortable, when another syringing finally succeeded in loosening the concretes of fine hairs and hardened cerumen. After loosening them, so as to be seen turned edgewise, I was obliged

to use a dentist's excavator, to seize and extract them from the meatus. They much resembled matured vaccine scabs of a large size. Next day the roaring was nearly gone. The ears were, after this, electrified twice a week, for a dozen times, during which the hearing improved. Have lately seen this lady, now over five years after the treatment, and she says her hearing is nearly perfect She has no noises, no vertigo, no difficulty with the ears worth mentioning.

*Those noises in the ear*, which may be included under the head of "*tinnitus aurium*," from the least to the most persistent, it is more than probable, are symptomatic of deranged or diseased conditions of the auditory nerve itself, when not the result of actual sounds from vibrations occurring within the head, neck, or thorax, as from pulsations of the carotid or other arteries, or from augmented heart action. Almost all irritations of the brain are attended with noises in the ear, whether originating in the brain or reflected to it. Tinnitus aurium is always present in acute inflammation of the membrana tympani, and of the cavity of the tympanum, and is coincident with all causes which exceed the natural pressure of the fluid of the labyrinth. Also, increased tension of the membranes of the fenestræ, or a chronic hyperæmia of the ear, if attended with thickening or rigidity, will cause most insufferable noises in the ear or head. So that while some of these cases are curable by electricity and other means, others are not.

A large proportion of all the ear cases coming to us for treatment, as thus shown, we cannot touch with electricity; as follicular inflammation of the auditory canal; or otitis externa, a diffuse inflammation; myringitis, an inflammation of the membrana tympani; aural catarrh of the middle ear; while the consequences of otitis externa, in its chronic form, resulting in the slit or ring-formed narrowing of the auditory canal, or in exostosis or hyperostosis, are equally unalleviated by any such means. But aural polypi, and nervous deafness, if uncomplicated, are completely under the control of electricity, when skilfully employed.

*Diseases of the Membrana Tympani.*—The drum membrane is composed of three important tissues: external skin, mucous

membrane, and fibrous membrane; and is subject to disease not rarely. The primary disease is simply an acute or chronic inflammation. The acute form usually manifests itself suddenly, and in the night; and usually arises from a cold, after standing long in a wind, or being chilled, or after a cold bath. There is a sensation of fulness in the ear, deafness, or noises, which is attended with deep-seated plunging pains, scarcely possible to bear, but which last from half a day to three days. From the commencement, the membrane loses its shining appearance, is highly injected with blood, and appears red as a lobster's back, and the concavity is diminished. The handle of the malleus is less easily seen, and at a later stage, the epithelium is loosened, the corium is red and swollen, and covered with secretion. The meatus, at first normal, is soon also swollen. If not early reduced, the tympanum may become ulcerated and perforated. At the best, it is usually a long time before the membrane recovers its former polish and freedom, so that the evidence of inflammation is seen long after it has existed. They are usually unilateral.

The prognosis is very favorable, if early and thoroughly treated. If neglected, the inflammation may become chronic, and extend to other tissues, or even be followed by *chronic otitis*. At once leeches should be applied close along in front of the ear, where they do more good than if put on under or behind the ear. To relieve the awful pain, fill the meatus with warm water. Give a saline, and other antiphlogistics, together with dover's powder, or morphine, to induce rest and perspiration. Use no electricity, no blisters, no excitants, no irritants.

*Chronic* inflammation of the tympanum is of more frequent occurrence, and is a most insidious disease. When uncomplicated, the patient may have it for years before consulting medical aid. The attention of the patient is first called to it, probably, by noticing the deafness in that ear, or the appearance of some discharge from it. Pain is only an occasional occurrence. On examination, we only find a slight moistening of the epithelium, and that mostly on the lower wall of the membrane, in consequence of its penetration here by the diseased secretion. This secretion is small in quantity, but pretty constant, and covers a portion,

more or less, of the membrane, which itself is now flat and dull in appearance, and the manubrium making but slight projection. In places it is often stripped of its epidermis, above and behind, and here it is red and swollen, the other portions being of a yellowish-gray color, and there can be seen numerous varicose vessels. These tumefactions may give rise to polypoid growths, which, though very small, may keep up the discharge.

Here is required the utmost patience; treatment may have to be protracted for a long time, and the patient kept under the watch and care of the medical attendant sometimes for years before it is entirely well. The ear must be kept scrupulously clear and clean, by means of a long and soft camel's-hair brush, moistened in a solution of borax and glycerine, or diluted liquor chlorinated soda, and daily attended to. After cleansing the external ear with soap and water, by aid of the little finger and towel, then the long camel's-hair brush and lotion should make the morning dressing. If exposed to wind, as from riding in an open carriage, &c., advise the patient to be always provided with a bit of cotton to put into the ear on such occasions. Then at night, with another brush, swab the ear out, just before retiring, with Goulard's lotion dilute one half with water. This *régime* must be followed perseveringly for months. Of course electricity is not here, or as yet, required.

*Catarrh of the middle ear* is usually the result of an abnormal condition of the *inner surface of the drum membrane*, (the mucous layer,) due to a propagation of disease from the outside of the membrane. The mucous layer on the inner surface of the drum is most developed at the periphery, and in catarrh of the middle ear — especially when this is chronic — we find this part losing its transparency, and becoming of a dark gray color, swollen, and separated by a distinct circular line from the rest of the membrane; but it requires a strong light to be thrown into the passage to see this well. These partial swellings cause the membrane to seem too flat, or too concave. Let the patient inflate the membrane by his breath, and it will be seen the better.

In *old*, severe catarrh, the entire surface of the drum membrane may become so hypertrophied that the mucous surface

alone is thicker, yes, many times thicker, than the entire membrane should be in its normal state. Where this state of things has long existed, there is likely to be, as the result, adhesions to the walls of the tympanum, and to the ossicula on the inner side, as also partial calcifications. This morbid process of internal disease may go on for a long time, destroying the organ for hearing, and yet scarcely showing through the membrana tympani, so that its outer surface may still present its natural shiny appearance, and even the view of the manubrium through it may be preserved. Like the cornea of the eye, the ear membrane may be perforated by ulceration, which, *if recent and small*, may be cured; but if large, or long standing, the less done the better. So that, on the whole, we find that the majority of the cases of so-called "*nervous deafness*," that present for the electric treatment, we can fairly diagnose as unsuitable cases for this mode of procedure.

*Otorrhœa* is a purulent inflammation of the middle ear, or of the external auditory canal. Congestion of the pharynx, and of the muscles acting on the soft palate and lips of the orifice of the pharyngeal entrance of the eustachian tube,—a catarrh,—is the almost invariable accompaniment of this inflammation of the middle ear; the affection, in fact, almost always beginning here, as after scarlet fever, humors, or cold, and progressing at first as a catarrhal inflammation, then passing along through the tube to the cavity of the tympanum, which, filling up, breaks through the membrana tympani, and we have internal otorrhœa. Electricity can do no good here.

*Aural polypi* are morbid growths, the products of the ulcerative process called *otorrhœa*, and are analogous to exuberant granulations. They are the result of a long-continued purulent inflammation of the cavity of the tympanum, or of the external auditory canal, but generally of the former. Their removal is important, and is safely done, but will not invariably restore the hearing, although it will improve it; and but rarely will complete recovery of hearing, in such cases, be finally attained. These growths are somewhat lobulated, and are always extremely vascular and gelatinous, and can be removed by the galvanic cautery, or by forceps; caustic being applied to the torn base

for destroying the roots, which tend to grow again. A strong solution of nitrate of silver, say twenty grains to the ounce of water, can be brushed once a week over the seat of the polypi; but if they are destroyed by galvanic cautery, no other dressing is required except to syringe the ear with warm and weak soap-suds to keep it clean, and an astringent wash of alum and borax, one drachm each to the pint of water, to dry it up. No electricity is to be used beyond the cautery, except, perhaps, after the discharge is dried up, and the polypus is obliterated. The remaining deafness, if attended with a coldness, and withered appearance about the ear, may be quickened to a considerable degree, and for durability, by judicious applications of electric currents. But while there is redness, tenderness, or discharge, electricity will only increase the activity of the diseased condition. In fact, electricity is admissible, and becomes valuable, only in cases of nervous atony, where there has been no alteration or destruction of the internal ear other than palsy of the auditory nerve, or general atony.

*Treatment.* — If no organic disease is existing in the head, no discharge or evidence of inflammation in the ear, faradaic electricity improves, and sometimes quite restores, the hearing. My practice is to place at first the two large sponge electrodes respectively over the ears, although but one may be affected, and transmit a brisk but bearable current through from ear to ear, and reversed once or so to arouse a general nervous activity; then changing the site of the positive electrode to the back of the neck, and removing the other, I insert into the ear affected a small electrode, previously wet with warm water, or, what is better, with a dilution of the *liquor sodæ chlorinatæ*, which saponifies the ear-wax, and allows the more thorough and general faradaization of the *chorda tympani* nerve. Then holding the sponge electrode or tip of the negative conductor, leading a very low current, in my own hand, (the positive large moist sponge electrode being at the base of the occiput,) I gently, and with extreme caution, touch my dry finger of the same hand to the wire of the ear electrode, and so gradually press it between my thumb and finger, dry, or more or less moist, and thus am

enabled to adjust any amount of current the most delicate case may require, and maintain it as long as desirable.

At first, there is a slight buzzing sound produced in the ear, when healthful and hopeful, which is followed by a scratching sound, and a tingling; if the current is increased there are pain, and a sensation, perhaps, extending to the side of the tongue; especially is this so when the primary current is employed. The duration and intensity of the current at each seance are to be determined by the effects; but generally from five to ten minutes in all, every other day, is sufficient.

Nervous deafness may also be successfully treated by electro-puncture when it seems to be owing to simple *paralysis of the acoustic nerve*. One method is, to introduce Itard's sound — which, of course, must be completely insulated, as by rubber or hard japan — through the nasal fossæ into the eustachian tube; and into this canal director a long and delicate acu-puncture needle is passed, until it is inserted into the mucous tissues at or within the tube leading to the internal ear; while the other, or ring extremity of the needle, remains out beyond the sound, ready to be touched by the electric conductor. Another tube or conductor, also insulated, is to be inserted into the external ear, through which is passed another needle, and so guided as to be implanted into the *membrana tympani*. Now, holding a pole of the battery (of *one*, two, five, or ten cups) in each hand, touch the tips of the needles simultaneously, first with one element, for a part of a minute, then with two, then more if no effect. The action of the current is strongest when the positive pole goes to the eustachian tube, and the negative to the auditory passage. But it is better to reverse them, from minute to minute, unless pain or inflammation, or a neuralgic state or tendency contra-indicates such procedure. Several days should intervene before the repetition.

According to Dr. Toynbee, of St. James's Dispensary, the most prevalent *local* cause of deafness in the ear is a chronic low inflammation of the mucous membrane which lines the tympanitic cavity; and he thinks by far the greater majority of cases commonly *called* "nervous deafness" ought more properly to be attributed to this cause. We should be reminded

of the *three stages* of this condition (while contemplating aid by galvanism) as being,—

*First.* Where the membrane retains its natural delicacy of structure, though its blood vessels are considerably enlarged, blood is seen effused into its substance, or perhaps more frequently at its attached surface.

*Second.* Where the pathological condition shows the membrane to be very thick, and often flocculent. In this state, the tympanic plexus of nerves becomes involved and concealed; the base and *crura* of the *stapes* are frequently completely embedded in it, while the *fenestra rotunda* appears only like a little depression in the swollen membrane.

*Third.* Where by far the most frequent and peculiar characteristic of this second stage of the disease, is *the formation of membranous bands between various parts of the tympanic cavity.* These bands are at times so numerous as to occupy nearly the entire cavity; sometimes they connect the inner surface of the *membrana tympani* to the internal wall of the tympanum and the sheath of the *tensor tympani* muscle. The place where these bands and adhesions are more frequently found by post mortem examinations is between the *crura* of the *stapes* and the adjoining walls of the tympanic cavity; at least, this was the case in twenty-four instances out of one hundred and twenty dissections. These bands of adhesion sometimes are found to contain extravasated blood, or scrofulous matter.

In the third stage of *inflammation* of the ear membrane, it becomes ulcerated; the *membrana tympani* is then destroyed, and the *tensor tympani* muscle is atrophied, (wasted.) The *ossicula auditus* become diseased, and are ultimately discharged from the ear; the disease often extending itself, now to the tympanic walls, and then affecting also the brain and other important organs.

Dr. Kramer, of Berlin, says, in regard to the "*appearance*" of the *membrana tympani* in health and in disease, that, "by the most careful ocular inspection of well nigh four thousand cases of ear diseases, which was repeated on some of these many times, I have arrived at the most undoubting conviction, that the '*healthy*' *membrana tympani* is entirely colorless, shining, and

diaphanous, having a well-marked concavity externally; and that, under the influence of the inflation of the tympanum, while the mouth and nostrils are closed, it is raised only into two round, longish swellings near the *malleus*, whence we may conclude that it is in a state of expansion.

"The '*diseased*' membrane, on the other hand, I have always found either inflamed, and then red as a lobster, or reddened, thickened, degenerated, swollen, or indurated; or, the inflammation having ceased, some of the numerous consequent changes of organization have been detectable; all these cases likewise excluding the idea of *relaxation* from or after inflammation, as its sequel." Dr. Kramer, it appears, arrives at the following conclusions: —

1. "The *magneto-electric* or *electro-magnetic* currents act decidedly as an *excitant* on the organ of hearing.

2. "This action is strongest when the magneto-electric current is conveyed *from* the mouth of the Eustachian tube *to* the external auditory passage of the same ear, instead of from one auditory passage to the other." Thus it should be employed in case of affections of the auditory nerve, in order to restore it.

3. "The exciting action of magneto-electricity is manifested by the convulsive twitchings and pains in the ear, the momentary *increase* of the hearing distance, (which, however, very soon diminishes again, or, though it continues some time, it does not amount to any great degree,) and by aggravation of the *tinnitus*, either at the moment or some time after the sitting, and then more frequently during the night.

4. "Electro-magnetism or magneto-electricity (i. e., *induction* currents) *does not* thus appear to possess any peculiar *strengthening* action on the auditory nerve. On the contrary, great care is necessary in the trial or employment of this form of electricity, not to over-excite the affected auditory nerves."

I have quoted the foregoing apparently adverse opinion as regards the employment of electricity here, because of the high authority. But evidently Dr. Kramer is far more familiar with the one side of the question than with the other, i. e., as regards the anatomy and pathology of the ear and its surgical treatment, than with the therapeutical manifestations of the *various* elec-

tric currents. I agree with him, that all *Faradaic* currents of electricity are usually painful and fruitless, when applied to the internal ear; but this is by no means true of the *primary current of galvanism* when properly managed, nor is it true of friction or static electricity, when the operation is performed by introducing into the meatus the little, sponge-tipped, ivory electrode, and then "*drawing*" *short* sparks from the projecting silver wire of the ear electrode, as also from the external ear, say for one minute. Thus have I restored many a one more or less to his hearing, and at the same time annihilated the annoying noises.

Deafness, depending on a true and simple paralysis of the auditory or acoustic nerve, may likewise be treated by galvano-puncture, and with the greater probability of success. After having tried the ordinary methods, by carrying the current to the *membrana tympani* in vain, I have resorted to this still more direct application of the galvanic current to the very parts affected. A sound, insulated except at its small button-like tip, is carried through the nasal fossa, backward, until it strikes and is supposed to be at or near the opening of the Eustachian tube, (not necessarily entering the duct,) while the other electrode is armed with an insulated acu-puncture needle, whose point for one sixteenth of an inch is naked gold, which is to be implanted into the membrane of the *tympanum*. Of the Daniell's improved battery I employ from two to five, or even ten or twenty elements, (cups,) by making fixed contact, say with the nasal electrode, and then touching for a second or two the head of the acu-puncture (needle) that is in the ear, changing the direction of the current from second to second, or every five or ten seconds at most. Sometimes flashes of light are seen, and there is almost always experienced a metallic taste, while the shock is sensible, and not very agreeable. Patients that are impressible, sensitive, or irritable, should receive but one or two such shocks, and from only three to five cups; while others will bear five, ten, or even the twenty. It can be repeated every three days, or once a week, according to the effect produced. In well-marked cases of deafness, where the milder method was insufficient, this has awakened an entire cure, that, so far, proves to be permanent.

Case of extreme deafness, and disease of both ears treated by electricity and cured. — Edward A. Goddard, of New York, aged twenty, was brought to me to receive treatment for almost total deafness; had suffered from disease of his ears nearly all his life. At three years of age he had scarlet fever; did not leave his bed for nearly a year; has had severe sickness since; is now decidedly a fine-looking young man, with fair skin and hair, but is evidently scrofulous; has had tumors cut from his neck, which were probably enlarged lymphatics; has been under the care of the most eminent men in our large cities, for this deafness, which was not a whit better, but grew worse, and was now almost a total deafness in both ears. During all these years there has been more or less discharge from the ears, and of late this appears to have been increased by the treatment from professed aurists. Such notes I gather from my case book.

This case was put under electro-therapeutic treatment (simply aided by a very weak wash of iodide of zinc) in February of 1859. He remained with me, receiving at first the daily *seance*, then on alternate days, then three, then two a week, — in all, for four months. At the end of that time his hearing was completely restored, together with a far more healthy tone in and about the ears; the discharges entirely done; the perforated tympanum healed! That both drums were perforated was proved by pouring a tea-spoonful of water, tea, or camomile tea in the ear, and it ran into his throat and mouth so readily, that he would always tell correctly what had been poured into his ear. This I saw repeatedly done, in the presence of other physicians. It is now more than one year since the recovery, and his correctness of hearing is scarcely equalled by the best. He is now perfectly well, and is a salesman in a store in Milk Street.

### *Indolent Ulcers.*

"Indolent ulcers" are very successfully treated by electricity. The first attempt was made in Russia, by Dr. Crussel, of St. Petersburg. He first employed, for this purpose, *the direct chemical action* of the constant voltaic pair, applied immediately to the patient; and he termed this method of his the "*electro-*

*lytic treatment.*" More recently it has been extensively employed in the hospital at Cronstadt, since the war, and that with very remarkable success in curing indolent ulcers. The results there obtained show that there is thus produced a rapid growth of healthy granulations and sound cicatrization of otherwise incorrigible old ulcers. Indeed, this method of treating ulcers has been occasionally put in practice in many nations, from our own country to the East Indies, and as far as can be ascertained, there is but one testimony, and that is, that no other means known in surgery is so capable of modifying the low, morbid vitality, and producing so uniformly a rapid growth of healthy granulations in old and ill-conditioned ulcers as by the continuous current of galvanism, and that, for example, from a *Humboldt battery.* It is rapid, and has no detracting contingency. It is not necessary to blister the skin. Indeed, we are to understand that here we do not employ the "electrodes" of any battery, but rather the plates themselves, which are applied to the sound surfaces of the limb or body, and so act. That is to say, two disks of metal — the one of silver, larger but thinner than a Spanish dollar; the other of zinc, and a little larger than the silver — are applied directly to the skin; the silver is placed a little beyond or below, just on the edge of the ulcer, while the zinc is some few inches above it on sound skin, and so placed that the sore is brought between the two plates. Only, the plates must be moistened and covered with rubber cloth, or oiled silk, and the whole bound closely on so as to *sweat* and keep moist. If not, they must be repeatedly moistened. The two plates must be connected by a wire conductor, and this wire must be completely *insulated* from the body. It is better to use the Humboldt battery, which is ready prepared, and admirable for this purpose — it is invaluable.

Indolent ulcers, then, can be readily aroused to take on a sound, healing condition, by means of galvanism alone, even where all other good treatment has failed. But, before an external ulcer heals, there is deposited the *cytoblastina*, in which organic and fibre cells are found. These, then, first give rise to *granulations*, which, as soon as they become level with the adjacent parts, are usually covered with a persistent membrane.

This process is called "cicatrization," or healing. The electrolytical and stimulating power of electricity by induction may be employed in almost all such cases, if gently performed, and with great assurance of success. But my own experience leads me to prefer the action of the little Humboldt battery for this purpose, applied so that the silver plate is below and beyond (but close by) the border of the ulcer, while the zinc plate is above and nearer the body. That is, the plates are to be so applied that the one is *on* the ulcer or below it, while the other is above, and thus worn for about half of the time. But the electro-magnetic currents simultaneously applied to the limb so affected, will also aid in vitalizing the flesh, and so fortify it against others breaking out afresh.

Nothing can compare with the rapidity with which a new character is given to the flabby granulations of a torpid ulcer by this little galvanic pair; even in the legs of old people, where, through want of vitality in the part, the sore will not heal. If very torpid, I apply the silver disk so as to cover the ulcer; i. e., lay the naked silver on the raw sore, for it is not painful, and it is often perfectly astonishing to see how quickly red and healthy granulations spring up under it, and the tedious sore is speedily and soundly healed. Should the healing be slow, however, then make a cantharides blister near by the ulcer, and remove the raised cuticle of the blister, and apply the zinc pad over this site for a part of the time. Thus, old, ill-conditioned, and "indolent ulcers" can be healed, that may have long resisted every other treatment.

### *Electric Moxa.*

Dr. Wells, an English surgeon, and Dr. Golding Bird, also, observed, some years ago, that if two disks, the one of silver and the other of zinc, are placed respectively on two blistered or otherwise raw surfaces of the body, and contact, as by a wire, is made between the plates, while the wire is insulated from the skin, and the action is thus maintained, say for two days, more or less, the surface beneath the silver plate was found healed over, while that under the zinc plate was converted into a superficial eschar. If the plates were replaced and maintained still longer, then the

eschar deepened, so as to extend to the sub-cutaneous cellular tissue, and to present all the characteristics of a slough, produced by chloride of zinc, or caustic of potash, except that the dead tissues were less compact. He noticed that the separation and cicatrization of such a slough is very tardy; but that it heals at once if covered in part or whole by the silver plate, the zinc being moistened and fixed any where upon the sound surface near by. The "*electric moxa*," thus made, is valued by some most distinguished medical men for certain cases of brain affection, as well as for pain and paralysis.

### *Galvano-Puncture for Aneurism.*

*Acu-puncture* may often be of the greatest service in some nerve affections, and in some cases it is quite adequate to success; it can also be employed in neuralgia, as where no electric machine is at hand, and where mustard, cupping, and the like fail to give relief. At least, this can be done to gain time, while getting an electric apparatus brought and ready for work. Then, by turning the switch of the machine so as to use only the primary current of the battery, by turning the connecting wires from the battery, not to and through the helix, but rather *directly* to the acu-puncture needles, and thus rendering them "*electro-puncture*," and they become instantly many fold more potent than simple acu-puncture, in overcoming obstinate local pain. But a current of more *intensity* will do better still.

I find the following case reported by Dr. Banks: "A surgeon was obliged to ride in bad weather, and that immediately after fatigue and perspiration. He was consequently soon taken with chills, which were quickly followed by some fever, general aching, stiffness, &c.; went to bed warm, but was no better: the case was regarded as an attack of a neuralgic and rheumatic character, affecting the aponeurotic or muscular structures. The surgeon thus portrays his own experience: —

"'On the fourth night from the commencement of the attack, I awoke with a drenching perspiration and extremely severe pains, with tonic rigidity of the muscles of the chest, more especially of the left side and shoulder. The pain, on attempt-

ing to move, was most excruciating. I found myself unable to expand my chest, and the breathing was wholly abdominal. I could not move. A sense of oppression and heat about the sternum kept increasing, and the dyspnœa became so urgent that I was fearful effusion was taking place in the pericardium. Dr. Banks was called in, and immediately proposed acu-puncture. In the course of a minute or two after the insertion of the first needle, which was pushed inward and downward until in contact with the lower portion of the sternum, and while I was sitting up, I experienced a sensation as if some strong, tense structure, which had previously bound down the sternum, had given way. This sensation was followed by a sense of approaching syncope, which was removed by lying down. While in the recumbent position, I now found, to my surprise and delight, that I could take a deep inspiration freely. But the muscular pain still continuing, and encouraged as I was by the great relief in my breathing already afforded, I now, on my part, anxiously wished for the introduction of other needles along the course of the fibres of the several muscles affected. This having been done, I felt, in the course of about ten or fifteen minutes, no uneasiness whatever in the chest, and was able to move about in any direction; indeed, so great was the relief, that after the removal of the needles, I was able to dress myself with ease. I felt well. On the following evening, and for about a week after, I felt some stiffness (but no pain) in the left side, which, with a second insertion of three needles, together with a slight anodyne, was entirely removed.

"'In this statement,' the doctor proceeds to say, 'I have endeavored to relate my case and personal experience in simple acu-puncture as faithfully as possible, and I find it difficult now to express in words the rapid and most extraordinary relief—as by a charm—that was afforded by the insertion of the needles. Beyond the narration of the case, I have forborne to offer any remarks.'"

Where there is a constitutional origin of such pain, in a recent or old case, as organic disease, *inflammation*, or inflammatory rheumatism, or hepatic engorgement, no permanent relief can reasonably be looked for from acu-puncture, nor even

from galvano-puncture. But as the editor of the London Lancet says, "In all cases of rheumatic and neuralgic pains, either acute or chronic, whether lumbago, sciatica, or pleurodynia, or pains of an erratic kind, no matter where situated, if not depending upon an inflammatory state, or upon a constitutional origin, or upon organic disease, and provided the patient is *most comfortable when warm, and is decidedly relieved by the application of heat* — in all these cases, it may, I think, be *confidently affirmed* that they will be singularly benefited by acu-puncture, which will not only afford relief, but in most instances will effect a cure." And where acu-puncture fails, there often galvano-puncture is entirely victorious. Besides, a less number of needles, and less length of time of insertion, and a less number of insertions, are required by the latter in order to be successful. (See p. 445.)

MM. Baumgarten and Würtenburg, after the fact announced by M. Schuh, "that coagulation is produced more promptly at the *positive* pole than at the negative, instituted experiments upon the action of each pole, taken separately." * They obtained the following results: —

1. If the negative pole of a galvanic battery was introduced alone *into* a vessel, the positive pole being at the same time applied against the neighboring parts, there was no coagulation.

2. The two poles being introduced at once into the vessel, produced slow, feeble, but rarely *complete* coagulation.

In order to turn these results to use, it becomes necessary to inquire, "What is the action of the poles upon albumen, fibrine, &c.?" M. Steinlein has undertaken this, employing Grove's battery, with poles of platinum and zinc: the first is positive; the second is negative. The experiments upon albumen gave the following results: —

1. If two conductors of platinum are plunged into a solution of albumen, no coagulation is produced; and test paper shows no reaction.

2. If the platinum needle of the *positive* pole be replaced by one of steel, then little bubbles are disengaged from the

* Teib. der Gesell. — Med. Times and Gazette, Dec. 16, 1854, p. 620.

negative pole, forming a thick layer, and the reddish test paper that is applied to the platinum needle (*positive*) becomes blue, and the steel needle becomes slowly covered by coagulated albumen, with no disengagement of bubbles. This needle also becomes bromeo-colored.

3. If a zinc needle be used in the place of the one of iron or steel, the coagulation is much more rapid.

It follows, from these experiments, that the coagulation of albumen takes place *only at the positive pole;* and that the coagulating force varies according to the nature of the metal electrode that is employed. The author then endeavors to explain these results according to physical and chemical laws; and he advises, in electro-puncture, that the steel needles should always be superseded by those of *zinc;* or rather, by needles covered by a layer of this metal.

The "galvano-puncture" should then be practised in the following manner: A certain number of needles, connected with the positive pole of a galvanic battery, are inserted into the tumor, whether the sac of an aneurism, or the cavity of an aneurismal varix. The negative pole should be supplied with a plate of platinum, which must be put upon the skin *adjacent* to the aneurism, after having augmented the conductibility of the epidermis by moistening it with a saline or acidulated solution.

*Aneurisms* of large arteries have been successfully treated by galvanic currents, and there are some such cases which must otherwise prove fatal, for they can be cured only by this means, if at all. Even these desperate cases present some chances of success, although not without some pain, and some little danger; and yet I believe not necessarily so, if carefully performed. The electric treatment here is based, then, upon the property given to living blood *while being traversed by an electric current*, i. e., of *its coagulating at the positive pole*. This, it is known, also takes place with albumen, in or out of living tissues, as Dr. De la Rive says, "probably by a secondary effect of an acid, liberated only by a law of action at the same electrode, from the decomposition of a salt, one of the constituents of the blood, and of albumen."

In this operation, it is necessary to introduce the electro-puncture needle well into the centre of the aneurismal sac. I say *needle*, for one is sufficient, although heretofore two have almost always been employed. That needle must connect with the *positive* pole of the battery, while the other electrode may be a sponge, or a metal covered with wet wash-leather, which should be applied to the skin *very near* to the former pole, *but on the opposite side of the aneurismal tumor* from the place where the needle enters. Then the continuous *primary* current from about twenty elements of Daniell's battery is required to produce the coagulum; and to this end, the current should be maintained for about twenty or thirty minutes. A half hour is usually better than less.

We have found this to have been entirely successful in a number of these cases; some, where compression could have been employed, but the patient preferring this method; but in other cases, where neither compression nor the ligature could possibly be brought to bear, as shown by some given illustrations. But first I wish to say that the *needle* is generally required to be of *gold* or *platinum*, at least so as not to oxidize in the blood. But my preference is for an untempered steel needle, whose point is heavily gilded or platinized for a quarter or half inch of its point, and then the remaining portion of its shaft heavily covered with hard japan, yet so as to leave a good metallic head or eye at its outer end, for contact with the conductor of the battery. These are indeed the same kind of needles I always employ for deep *electro-puncture*. If the japan is well baked in, the shaft of the needle is polished, and yet completely *insulated*, so as not to injure the walls of the sac, in the least.

In the London Lancet of July 30, 1853, p. 94, is reported a case of aneurism of the external iliac, that was cured with electro-puncture by means of the secondary current of *electro-magnetism!* The patient was a sergeant in the Madras Fusileers, and as no other attempt at radical cure was thought justifiable, Dr. Eyere proceeded to operate as we will show in his own words: "I had met with some cases recorded where galvano-

puncture was successfully resorted to. It was either in aneurisms of small vessels, such as the temporal, or at least where the compression of the vessel could be for the time maintained; for this was then regarded as essential. In this case, owing to the situation of the aneurism, it was impossible to effect good compression; nevertheless I thought, under the circumstances of the case, I was warrantable to give electro-puncture a trial. On the 4th September, two long fine needles were introduced an inch within the aneurismal sac, each being connected with the wires of a galvano-magnetic machine. The object was to avoid shocks, and merely to pass a current through the sac. Pressure as firm as could be borne was made above, but it was not sufficient to stop pulsation in the tumor. The sensible effect of *this* kind of electric current was, pain in the groin, and violent agitation of the whole body. At the expiration of twenty minutes, the needles were withdrawn. The tumor was still pulsating as before. Strict quietude was enjoined. For three days after, neither did the aneurismal tumor nor his general health give indications that any effect had been produced. On the 8th it is noted, 'Tumor painful; is in a nervous and depressed state; cannot sleep.' This condition passed off, and nothing presented worthy of notice until the 12th, when pain in the tumor recurred, and he was again in a nervous and restless state. Leeches were applied, and sedatives administered. September 16th, there was much constitutional disturbance, with violent inflammation about the hip. Treated with purgatives and refrigerants. On the 19th, the inflammation was subdued. The tumor was now larger, but the pulsation not so strong. Digitalis and morphia prescribed; 27th, tumor sensibly harder, and the pulsation fainter. October 6th, pulsation to-day is very faint; 8th, the pulsation is scarcely to be felt; 11th, no pulsation for the last three days; the tumor is hard and diminishing; no pulsation can be heard by the stethoscope for two inches above and below the sac; 20th, no return of pulsation, and the tumor is gradually lessening; limb has lost the numbness so long felt in it, and only complains of want of power to walk. The remains of the aneurismal sac feel like an enlarged inguinal gland, and are about the size of a nut. There is œdema of the leg still.

"In the case whose treatment by galvano-puncture, led me to try it in Sergeant H., the cure was effected by a *continuous* and *primary* current of electricity, producing immediate coagulation of the blood in the sac. One may infer this by the rapid effect in a case of sub-clavian aneurism: 'The tumor was felt to be becoming gradually solidified; and even before the withdrawal of the needles it had become perfectly solid, and pulsation was no longer felt in it.' In another case of popliteal aneurism, a like rapid effect was not attained, (attributed to the agitation of the patient;) still in twenty-four hours pulsation ceased, and in seven days he left the hospital, walking quite well.

"This was not the *modus operandi* in the sergeant's case, but inflammation, and the deposit of lymph that occurred, filled up the sac. This latter mode was a hazardous one, and was not intentionally induced. The electro-magnetic effect was probably too violent to produce the former, though the machine—an electro-magnetic coil (helix)—was used at its lowest power. Indeed, I thought at first too little had been done; but when I found the external sign of the inflammation going on within the sac, accompanied by such constitutional disturbance, I began to fear that too much had been done. I watched with solicitude for the dark spot on the tumor—the forerunner of sloughing. Happily, the threatened danger passed away. The patient was of sound constitution; he lay in a spacious, well-ventilated ward, and the season was favorable. Under opposite circumstances the event might not have been so propitious. I should reluctantly resort to it (electro-magnetism) again, unless I had the proper primary electric current under my command."

### *Un-united Fractures of Bones.*

A case of fracture of the thigh bone is reported by Dr. Hall, of the York County Hospital, as having been cured by galvanic currents, in the following manner: He introduced a fine but long acu-puncture needle into each side of the limb, so that their points came near the inter-space between the fractured ends of the bone, and thus he passed, for five minutes, a current of

moderate, continuous, and *primary* galvanism. This operation was repeated every day for about a fortnight, and a cure resulted. The fracture of this leg bone having been very movable, and having existed thus un-united for more than a year, had resisted every other means that had been attempted.

The author has seen but few cases of un-united fracture of bone since he has been more particularly interested in this special practice of electro-therapeutics; but he can add, that no case of these few has ever failed to be speedily united by means of electro-puncture, aided by the passage of some stronger currents, primary or secondary, through the skin and muscle coverings. The following is given as the mode of proceeding:—

Captain G. fell, more than two years before, from the staging of a new ship he was then building, and broke his thigh at its upper third. He was cared for, the best possibly, by our most able surgeons; but he was restless and irritable under the long restraint, and, after months, it was found that the bone was still un-united, and, therefore, the seton, with tonics, together with magneto-electricity, were resorted to, and persevered in for a long time. His limb had been so long retained in splint, however, that pseudo-anchylosis of the knee joint was the result, and this then rendered the fracture an almost necessary artificial joint, and still more hopeless of ever being kept quiet long enough to unite. But, in the first place, I had provided for the captain the improved surgeon's bed for fractured limbs, upon which he was comfortably adjusted for a siege of twenty-one days, which was all I demanded for a fair trial in his case, and at the same time prognosticated as favorably as I could. To this he agreed to submit. The broken right thigh was then prepared with the sustaining broad roller from toes to hip, and the limb placed once more in the same excellent splint that had been used by the surgeon in the first instance when he set the fracture. Then the long size electro-puncture needles were inserted through the roller, skin, fascia, and muscles, the one entering rather at the upper inner edge of the *rectus femoris* muscle, avoiding the femoral vessels and nerve trunks, and carried down until its point touched the bone as near the fracture as possible, while the other needle was inserted on the outer side of the

thigh, through the *vastus externus*, and pushed forward until its point reached the bone. These needles were of fine gold, and insulated, except at their points; or *un*tempered steel needles, some three or four inches long, heavily gilded for a half inch at their points, and their shafts covered well with hard japan for insulation, will do well. The insertion of the needles was attended with no pain worth mentioning, and the primary current, from ten elements of Daniell's battery, was brought in contact with the heads of these needles continuously for five minutes, and so on three times at the *seance*, and thus repeated every three days for the first nine days. After that, the current was applied daily from large soft sponge electrodes, as employed for neuralgia, to the loins and limb through wet spots on the roller. Thus the case was treated until the twenty-one days expired, when the patient was set free once more from the splint and bed restraint, and to our mutual gratification, the thigh bone was found fairly knit together, and the leg was stiff. The subsequent treatment at the knee joint and about the limb was the same as would be instituted for an old rheumatism. In a fortnight more, the limb felt to him more secure and comfortable, and what was quite as pleasing and surprising, the pseudo-anchylosed knee also began to show a loosening and joint-like action. This became more and more apparent, so that in three months the captain was prepared to think of the sea again, as he now walked well, and accordingly arranged for an East India voyage.

### *Electric Cautery.*

In 1855, Dr. Middeldorpff published a very valuable work on the subject of Galvano-Caustics. The instruments he used for these new and peculiar operations in surgery he termed "galvano-port-ligatures," galvanic cauteries, galvanic setons, &c.; drawings of which, accompanied with a paper from Dr. Coolidge, of Chauncy Street, was published that same year in the Boston Medical and Surgical Journal. These instruments should be made of *heavy gilded* copper, tipped with platinum wire, when used as a loop or saw; but when used as a probe

or point, then tips of *platinized*, untempered steel are preferable. The advantages of the galvano-cautery in all this class of operations, according to Dr. Middeldorpff, are, the exact intensity of heat and precise line of limitation of the effects of the operation; the rapidity and cleanliness of the action; the total absence of hemorrhage; the ability to reach and remove the deep-seated parts, such as it is impossible to get at with the ligature or knife; and, finally, the uniformly good character of the fleshy cicatrix. He reports numerous and varied cases so treated, and with very uniformly good results. With it he claims that we can cure neuralgias in the most desperate cases, even where nothing but destroying the nerve can relieve; we can use it as a *moxa*, or for certain rheumatical and superficial paralysis; for *nævi*, *polypi*, and other vascular tumors; for gangrene, ulcers, cancers, and especially for *fistulas*. He succeeded in the bloodless amputation of a deformed finger in a young lady, cutting not only through the soft parts, but also the bone, which rapidly got well.

Dr. Marshall and Dr. Amusat, and some others, choose a short bit of platinum wire as the electrode, about one fiftieth of an inch in diameter, and not more than three inches in length, for curing ulcers and removing growths upon the unhealthy *cervix uteri;* also for removing cancers from those parts.

Dr. E. H. Clarke, of Arlington Street, Boston, professor in the medical department of Harvard University, informed me, a short time since, of his entire success, by this means, in removing a deep-seated tumor from the ear passage, that had thwarted all other efforts, or even attempts, *because of its hemorrhagic nature* — a profuse bleeding occurring on the slightest touch. He states that this cautery left only a gray eschar on the side of the bony canal, near the *membrana tympani*, which did not bleed. The result appears, so far, to be a complete cure. I should have mentioned that in this case Dr. Clarke first passed the loop of wire over and beyond the little tumor, and then, as soon as contact was made by an assistant, the platinum was instantly seen to be red hot; he drew it forward gently, when it shaved the neck of the mass clean and close to the bone.

Not for all cauterizations, I conclude, but for certain cases, the galvanic cautery can be employed with decided advantage. It acts rapidly and with energy; it causes but little pain, and no hemorrhage; its action may be exactly limited to the precise spot or line; and it always favors the growth of *healthy granulations*, for it probably modifies the vitality of the diseased part; and, finally, it is no way so terrible to the patient as the red-hot iron, or the *aqua fortis*. It has been used, and approved of, also, by Amusat and Nelaton of Paris, Hilton and others of England, and Sedillott of Strasburg. There appears to be but one single drawback to the very extensive employment of this excellent therapeutic in surgery, and that is, the difficulty of having sufficient battery power always ready for action. And this objection must greatly prevent the employment of this agent, otherwise so desirable, excepting in hospitals, where it certainly can and ought to be always in ample readiness contiguous to the operating room.

*Urethro-vaginal fistula* has been operated upon with the galvano-cautery at St. Bartholomew's Hospital, by Dr. James Paget. The case is reported in the Lancet, June 9, 1855. The woman had never been married, was of about thirty years of age, was healthy, but had an old-standing and troublesome fistula between the vagina and urethra. As the case had been the subject of repeated and fruitless operations at various hospitals, and very many modes of cure had been tried in vain, Dr. Paget had recourse to the electro-cautery. The case is one of very great interest, because it shows the adaptation and beautiful application of localized and *concentrated* electricity in surgery. The writer goes on to say, —

"We lately spoke of the usefulness of the actual cautery in hemorrhage, as after lithotomy, and in chronic synovitis. Every one, however, must have observed the clumsiness and hurry with which the red-hot irons are taken out of a smoking brazier, and the horror they create in the patient's mind. The galvano-caustic, on the other hand, requires no fire, no smoke, &c. The essential part of this apparatus, not unlike a glazier's diamond, or ordinary port-caustic-case with two wires run through it, may be carried in a pocket-case. When in action it applies a little

coil of platinum (twisted around a bead of glass or porcelain, about the size of a small pea, and of a *white heat*) to any part, or for any length of time that may be necessary. In the present case the effect was almost like magic. The incandescent little '*pea of fire*,' produced within the *speculum vaginæ* by the operator in an instant, quite lighted up all to be seen, and plainly showed the amount or extent of disease, almost as in a diagram.

"The plan of operation, to which we would revert for a moment, was very simple. An ordinary galvanic battery, of some half-dozen plates, was placed on a chair at the side of the bed; the two wires (conductors), the one attached, the other in the operator's hand, were next arranged. The second conductor wire only required to be pushed into a hole at the opposite end of the battery, by the left hand, and the operator could have instantly produced in his right hand this little ball of fire, at a white heat.

"The woman was next placed on her hands and knees in bed, without any exposure. The speculum was introduced, when the vent or fistulous opening was at once seen to be about a half an inch in extent. The circuit of the battery being now completed, the coil of fine platinum over the bead shone at once with almost too much light, reflected as it was from the glass mirror and silver of the speculum. Dr. Paget then carefully pencilled the edges of the fistula with this new, and we think improved, actual cautery, just as if it were a pointed piece of nitrate of silver. The woman, strange to say, did not feel the least pain — a *peculiarity*, it is said, of the '*white*' heat, as contradistinguished from that of a lower or red heat. She did not require ether, and after the operation she seemed as if nothing had been done to her. We mention these particulars, because such an improvement as the galvano-caustic, over the old red irons, cannot fail to be of use in burning out the seeds of cancer after removing a cancerous tumor, or in destroying even to the minutest point or speck the various morbid growths for which the actual cautery is generally used.

"This operation was performed May 18. On the 21st, when visiting this woman to-day, she expressed herself quite a new being, as she can now retain her urine three times as long as she

did formerly. It is too early, however, to form a decided opinion. — 23d. Marks of improvement are beginning to be quite perceptible in the woman's countenance. She states that she has not been so well for 'years and years.' — June 4. Dr. Paget is quite satisfied with the good result of the operation. The remedy in this case has been an interesting one, as a galvanic experiment, free from pain, and ultimately effectual after other operative proceedings had failed." (See pp. 327, 332, 388.)

### *The Faradaic Process in Tooth-Extracting.*

The magneto-electric machine that I employed while making my researches in this particular line, the year immediately after my return from Europe, was a very simple and neat apparatus, and is now extensively manufactured by Mr. Hall, for dentists' use. It is the neatest machine for office practice, either for the physician or dentist, that I have ever seen. The helix is *long*, and completely covered with a silvered band and ivory ends, admitting a very delicate graduation of the current, by the adjustable rod or bundle of soft iron wires within. A Smee's battery is employed to run the helix, and requires cleaning only once a week or month. One part sulphuric acid, with fourteen parts water, runs the battery suitable for dentists' use. The positive (weaker) pole is to be attached to the forceps, while the negative (strongest) pole is either applied to the nape of the neck, or under the ear, of the side the tooth is to be extracted, or else held in the hand of the patient *on the same side* the tooth is situated. The adjustable attachment or contact of the negative conductor with the handle of the forceps is conveniently made by a few inches of rubber tubing of a size that will just slip over the end of the handles. This rubber tubing I found to be at the same time the best thing for insulating the instrument from the operator's hand. The outside of the forceps, about its joint from the rubber handle covers, to the very edge of the beaks or blades, should be well covered with varnish, or, what is better, with hard japan varnish, so as to insulate every instrument perfectly from the lips, cheek, and gums; but *the inside of the beaks* or jaws, on the contrary, should be the clean steel, (even clean

from dried blood,) so as to *conduct* as *surely* to the periosteum of the tooth, as the outside *insulates* from the gum.

The wire tip of the conductor can be slipped under the outer end of the tubing that covers the handle, and this wire can be pulled out and slipped under the thus prepared handles of any other forceps in an instant. The conductor that leads to the forceps should be made to pass through an interrupting footboard, such as is used for telegraphing purposes, so that the current can be made or broken instantly, at the command of the operator.

Another precaution I would here mention. I have found that when there is oil in the joint of the tooth forceps, one blade is liable to be thus insulated from the other, and so fail to convey the current to both sides of the tooth. To avoid a failure from this cause, I have the terminal end of the negative conductor provided with two terminations, which are some six inches in length, each of which I tuck under the end of the rubber of each handle of the forceps to be used. This simple arrangement alone will nearly double the uniformity of success in this delicate operation. So much for the preparation. Next, for the operation.

First, the electro-magnetic machine should run with fine vibrations, and at a very moderate *battery* power, but with a smooth and even current. Next, the intensity of the current should be graduated down to the nervous impressibility of the patient. The adjustable rod, or bundle of soft wires, are graduated and marked off with sixty degrees. Some young ladies, and some men, too, can bear only ten degrees; others will require twenty; and some hardy nerved or phlegmatic temperaments can not only bear, but say they do but just feel, forty degrees. For the young operator, it is well to let the patient take the two poles in his own hands, and then adjust the strength of the current by the magnet until he or she can very agreeably feel it, but no more. Then adjust the positive pole in the patient's hand, or over the *portio dura* nerve, or on the nape of the neck, while the heel of the operator rests on the floor near the footboard, ready to make or break the circuit of the current at any moment. Now, when *quite sure* that all is right and ready, carefully slip the forceps on the neck of the tooth, until it rests gently against the gum,

ready for a better or deeper hold; and as this is being done, that instant *let on the current, grasp the tooth, and pull* systematically and carefully in the same order and about as quick as a person can say, *one, two, three;* so I say, make contact (press the foot) for *one, grasp* the tooth for *two, pull* with a waving motion for *three.* The two former motions can be practised until exact, and without a failure. The latter cannot always be *limited.*

The current seems to *mask* the pain for about five seconds, as near as I can judge from all my trials. If, then, the current was let on right, and the tooth fang leaves the alveoli and gum before that time is up, it is a success. When the tooth *hangs hard,* and is slow in yielding, I break the current, slack the pull, and then make it again with a renewed pull. So if the battery current is too strong, or is irregular, or fails to pass; or if the forceps are not *perfectly* insulated from the operator's hand, as well as the patient's lips or inside of cheek or gum; or if the current is let on too soon, or, on the other hand, if it is let on too late, i.e. only after the *pain* is already established from the crowding forceps upon the inflamed gum,—in either case, I say, it is *necessarily* a failure. But when all these conditions are complied with, which is only like any other exact but eminently practical art, there is a success that may be called *complete* in every eight cases out of ten. I would not include cases of "fang pulling" when there is a protracted process of "getting hold;" but in fair cases, when the adroit operator can readily adjust the beaks of the instruments on "a good hold," the operation is then more like pulling wooden pegs, than like tearing bone from bone. For single tooth extraction, my experience leads me to say, electricity is far preferable to ether.

At the University College Hospital,* Dr. Marshall has made some very interesting trials as to the efficacy of the electric current in *benumbing* parts ready to be submitted to surgical operations by the knife, the idea involved in these trials being of course derived from its conditional advantages in "tooth-drawing." As many as nine operations, requiring incisions of

* Lancet, Sept. 18, 1858, p. 297.

various kinds, have been thus performed. Excepting where the current employed seemed to be too strong, the pain of the incisions appeared, on the whole, to have been so modified as to be somewhat more endurable than is usually the case. In one instance — that of the adipose tumor — the cuts were very slightly felt. There was *no* instance, however, of complete anæsthesia; and it would be premature to flatter ourselves that, in regard to the effects of electricity in *cutting operations*, any thing more than a modifying influence had yet been certainly obtained. Electricity, in any fair sense, is *no way* paralyzing.

Dr. John Snow concludes that the sensibility of the body may be "*couched*," suspended, or destroyed in two ways. First, it may be accomplished by the direct effect of some temporarily *benumbing* agent on the *extremities of the nerve* ramifications of the part. Secondly, by the effect of the agent on the *centres of intelligence;* i. e., by the destruction of consciousness. This may be illustrated by contrasting the probably different effects of amylene and ether. The former acts mainly on the periphery twigs of the sensory nerves. *Ether*, on the other hand, *suspends sensibility in proportion as it destroys consciousness for the time. But electric currents cannot produce complete anæsthesia at our will, either uniformly or safely.*

This, although but a partial improvement, yet, like etherization, is of American origin. It can be shown that I was experimenting in this line all the fall and winter before Dr. Francis made public his experiments in Philadelphia, being led to it while making trials with different electric currents in surgical cutting operations. I found that the periosteum of bones almost every where received a peculiar impression, not exactly painful, but decidedly sensible, the instant the edge of the knife or scalpel reached it, while conveying a *gentle* current of electricity, *provided* the blade and back of the knife were insulated, so that the current could not reach the wound except at its very edge. This was most noticeable in opening felons. Being then, as now, perfectly aware that *such currents of electricity have no sort of paralyzing power*, yet it struck me that if this instantaneously produced peculiar *impression* could be brought to bear upon the periosteum of the tooth *while it is being extracted*, it

might be found to *modify* the sensation of pain. I did not expect to find such a current, in any absolute sense an anæsthetic agent; and those who do, are hasty in conclusions, or else know too little of the laws of electro-physiology. I claim that here it is through the periosteum of the tooth, that the *pre-occupying impression* of Faradaism supplants the quickly succeeding and partially simultaneous painful impression of extraction. The two impressions appear to be something like a race; but in order to have the *electric impression* beat the *pain impression*, the former must have a trifle the start.

I say it is probably through the peculiar properties of the periosteum or *surface* of the tooth, that this *pre-occupying* or vicarious impression overshadows the pain of tearing, and is not through the contained pulp and nerve. A recently extracted tooth, when cleaned and well dried, is almost as complete a non-conductor of the electro-magnetic current as is ivory. I do not say it is completely so, but I do say it is a very poor conductor, and cannot transmit or convey the current through its body so amply as to account for the attending phenomena. It is more probable that the current does not penetrate the tooth, but mainly passes down its sides to its nerve at its exit from the fangs, and to the contiguous alveoli. This may be true, or it may not; but such were the reasons that led me so early and so far into these trials.

When several letters patent were proclaimed for the process, and litigation appeared likely to follow, I dropped this whole branch of experimentation for other fields in electro-physiology and therapeutics. At that juncture, however, the author made a report of these so far ascertained facts before the Suffolk District Medical Society, exhibiting the teeth thus extracted without pain, from some sixty patients, and explaining the *modus operandi*. Some of our best dentists, who are experts in surgical dentistry, are now making use of this method in all suitable cases with highly satisfactory results. Dr. Keep, long known in Boston as one of our most skilful dentists, has just informed me that my method for the *Faradaic tooth-extracting process* removes "the dread of tooth pulling" in one half of the cases, expedites

the process in quite a number of instances, and averts the necessity of administering ether not unfrequently.

Dr. J. N. Hearder, of Plymouth, says, however conflicting the evidence afforded on the subject, the failures appear to indicate little more than the absence of an efficient apparatus, or of the want of knowledge or experience in the application of it. Much more must be done in the way of investigation and *careful* manipulation, before individuals or societies will be in a fair position to pass judgment on the value of an agent so powerful, and, when in the right hands, so efficient. *The investigation of the causes of some of the failures shows, that the right effect would have been produced, had the right method and manipulation been adopted.* Much of the experience on this head will necessarily be empirical until the relations between cause and effect here shall be so far determined as to establish a sufficiently accurate system of prognosis, and definite method of procedure.

One step towards the attainment of success in this speciality will be the employment of a *suitable* electro-magnetic *apparatus*, such as is capable of nice adjustment and easy application. The graduation of the current must be as *minute* as the manipulation is *delicate*. I have been in the habit of employing electricity for certain cases of toothache during the last *thirty years*, and have relieved hundreds of cases, most of them permanently, many of them for a considerable period of time, some only temporarily, and very few not at all.

The cases of toothache which yield most readily to this treatment are those in which the pain originates in the tooth itself. Those in which the pain results from a neuralgic affection require a modified and more continuous treatment; but, as might be expected, in those cases where there is *abscess at the root of the tooth*, the pain is usually increased. Dr. H. says, —

"My mode of electric treatment here is to apply a metal disk, covered usually with moistened cloth, and connected with the *positive* pole, which is placed on the back of the neck; placing a similar disk connected with the negative pole either on the tooth itself, or on the gum, or by passing this second disk along the course of the nerve, or its branches, exteriorly on the face. The degree of electro-magnetic power that is necessary, *is very*

*feeble*. So efficacious is this remedy for *toothache*, that some of my own children, who suffer occasionally from defective teeth, apply it for themselves for a few minutes, and return to their room relieved from pain, and sure of a comfortable night's rest."

We have just said that the *Faradaic tooth extraction* is of American origin; but we see that a wide attention is awakened in England on this subject. Mr. Sharpe, the dentist for the Chester Infirmary, says he has lately "extracted one hundred and fifty teeth from people of all ranks, of both sexes, and of every age. The testimony of each of these has been mostly satisfactory; a current of electricity having been directed through the tooth to be extracted; some persons said they experienced pain, but not so much as usual; others, that they felt no pain whatever. Some patients have said, they were 'conscious of the pull, but the customary *pang* was absent.' The exclamation of many, after the operation, has been, 'O, how delightful!' 'How very nice!' '*How very wonderful!*' &c. One gentleman, who was rather sceptical, after having a tooth extracted, said, 'Well, I would not disbelieve a man now if he should tell me he had learned to fly.' Feeling desirous of getting as satisfactory evidence as possible, I persuaded my youngest son, who is not more fond of having his teeth drawn than other boys of his age, to have a temporary molar tooth removed in this way, in order that he might be able to tell me what he thought of it. As soon as the tooth was out, he exclaimed, '*That's the thing. It will do it, papa.*'"

Dr. Lobb, of the Western General Dispensary, says, "I have now used the *inverse continuous current* of electricity (galvanism) for more than twelve months, for the cure of *some forms* of neuralgia, toothache, &c. I have never used it to prevent pain during the extraction of teeth, but from what I know of its success in toothache, I have no doubt it will yet be found to be perfectly successful." Dr. Richardson, physician to the Royal Infirmary, &c., says in a recent paper, "The present unsatisfactory mode of preventing pain in surgical operations must unquestionably be ultimately superseded by some better process. It will be read of, some day, as a rude science that leads the whole human organism into the *realm of dissolution*, in order

that one poor molar may be dragged out without a flinch." Dr. Arnott thinks it is even so now. Any mode of producing local anæsthesia, — I mean complete local anæsthesia, — without injury, lies open, at this moment, as the grandest practical discovery to be made in medicine; and he who makes it can be grudged his well-earned fame by none but the selfish and the foolish.

### *Galvano-Cautery for the Teeth.*

Who, of our own dental surgeons, was the first to use the elegant *galvano-cautery* for destroying the sensitive nerve-pulp of decayed teeth, either to relieve pain, or as preparatory to "filling," I am not informed; but it appears that Dr. Thomas H. Harding, of England, was the first to put it in successful practice in that country. I admire what he says of his experience in this matter. He remarks that Dr. Marshall's paper in the London Lancet, in May, 1851, first suggested to his mind this excellent method as the more certain, rapid, and safe manner of effectually obliterating the nerve of a decayed tooth. Many methods have been from time to time employed to direct the "galvanic heat" upon the tooth-nerve, but they have mostly been either inefficient or badly managed.

Speaking of other methods where the tooth is liable to be injured, as, by the "actual cautery," the substance of the tooth is *carbonized*, Dr. Harding says, now, all this liability is completely removed by using the electric cautery, which can never be surpassed for convenience and ready mode of application, besides possessing a steady, uniform, concentrated, and constant degree of heat, which can be continued at pleasure until the proper effects are obtained, and then it can be as magically stopped by breaking the contact of the conductor. It has the advantage, also, that it can be introduced unseen into the patient's mouth, and actually placed within the cavity of the tooth, before it is made to become incandescent (white hot) — an advantage that, for this particular purpose, cannot be overestimated by dental surgeons, who are so frequently called

upon to destroy a tooth-pulp. The nature of the apparatus which he employs for this purpose is thus described: The battery is what is termed *compound*, i. e., consisting of six pairs of large plates, the one of zinc covered with quicksilver, and the other a platinized silver, which are contained in six cells, or gallon jars of crockery or glass, (called Smee's battery,) which are set in action by one fluid, viz., dilute sulphuric acid. The battery may of course vary according to the choice and taste of the operator; but it is desirable to render it as elegant and as simple in arrangement as possible. When I first employed the electric cautery, I used a battery of two (large) pairs of plates in a single cell. I now prefer the larger battery, of six cells, because a large battery, with weak acid, will run longer than a small (or single cell) battery, with strong acid; besides this, the action of the battery *is more uniform*, and lasts much longer. A Smee's battery is the best for dental purposes. It is always clean, ready any instant when wanted, and has the advantage, moreover, of cheapness. Grove's battery is not so adapted to these purposes, because it is troublesome, and often gives out fumes of nitrous acid, which is decidedly objectionable. There is none of this trouble from a Smee's battery.

Dr. Braithewaite, in his "Retrospect," Part 36, page 296, makes some capital extracts out of the Quarterly Journal of Dental Science, from the pen of Dr. Underwood, on the "Treatment of the Exposed and Diseased Dental Pulp." The writer there says much in these words: The parts of the teeth possessing nervous *sensibility* are the *pulp*, or, as it is more generally termed, the "*nerve*," as also the *periosteum* and *the fine membrane* situated between the enamel and the bone. Mr. Tomes considers the sensibility of this part of the tooth to be owing to the nerve fibrils in the dentinal tubes. He says the greater degree of sensitiveness observable in the dentine, immediately below the enamel, that is, at the point of ultimate distribution of the dental tubes, and consequently of the nerve fibrils, may be fully accounted for on the supposition that the latter are organs of sensation.

No doubt the nervous filaments passing through the *tubuli*,

or else through the intercellular substance, form a plexu under the enamel which is highly sensitive. Every prac titioner knows, that in excavating some teeth there is no pai whatever felt on introducing the instrument even into th pulp cavity itself; but that a sharp pang is experienced imme diately if we touch the spot where the dentine and enamel com in contact. The sensibility, however, of this membrane nee not interfere with plugging the tooth; no ill effects will follo it. That which is *toothache*, in the general acceptation of th word, proceeds rather from the actual exposure of the denta pulp, and is characterized by acute and violent pain. A por tion of food, or any foreign substance, entering the cavity of th tooth and coming in contact with the pulp,—any thing very ho or cold,—in fact, if only exceeding in either of these respect the natural temperature of the mouth, immediately produces paroxysm of pain along the whole course of the dental nerv extending up the head, &c.

There are three modes of treatment open to the dentist i these cases. Should the affected tooth be one of the incisor or canines, the pulp may be removed either by a five-side broach, or by pushing a straightened small fish-hook up th cavity of the tooth, giving it then a half turn, and withdrawin it quickly, and in nine cases out of ten you will bring alon the nerve with it. The bleeding then may be stopped by th application of camphorated spirit; after which, remove all th carious bone, dry out the cavity, and plug it. The second pla is to destroy the nerve entirely. The third plan is to rende the exposed surface insensible.

After speaking of the employment of arsenic, creosote, tanni acid, quicklime, and nitrate of silver, he proceeds to say, "Th actual cautery (by galvanic heat) may often be resorted to wit *great success* in instantly producing an eschar on the sensitiv pulp, and in a few days the tooth may be filled. You fir apply the wire of the cauterizer to the affected pulp *unheated* then, by touching a spring, contact is made with the battery and the wire is instantly at a white heat. Care should be take not to wound the internal (deep) part of the pulp."

"The affected tooth being carefully examined, its cavity is to be well dried out and cleansed. A soft napkin is introduced, to protect the mouth; the platinum point of the instrument is then passed over or into the cavity of the tooth and when all is ready, and well seen, contact is made, and it is thus heated; and from the brilliancy of the clear and distinct light there produced, the tooth-pulp is all the better seen, and can be accurately *touched*, and only so, with the heated wire, when the whole, or the particular portion of it required, is instantly destroyed."

It is well to mention, that caution is to be observed not to injure the solid part of the tooth. Particular care should be paid to this point. This will not happen unless the application is prolonged, which is almost never required, and if special care be observed to have the wire at a *white heat*. This is the more necessary, to produce the sure and speedy destruction of the soft part touched, which indeed is effected almost instantaneously. "In one instance," says Dr. Harding, "that of a lady for whom I nipped off the crown of an incisor tooth, for the purpose of fixing some artificial teeth, and so exposed the pulp of that tooth, I applied the electric cautery at barely a red heat, owing to the feebleness of the acid in the battery. The unfortunate consequence of this was, that the dental pulp became attached to the end of the wire, and was actually drawn out of the tooth entirely. This has been preserved as a pathological specimen. It gave some slight pain for the moment, but mere nothing in comparison to the pointed steel, or silver wire, as used by most dentists. This perhaps unimportant accident, I think, would not have occurred had the cautery been at a white heat, as it would then have as completely as quickly destroyed the soft part with which it came in contact."

"The *effect* of this operation," he says further, "is the rapid annihilation of the pulp of the decayed and condemned tooth. Not the whole of the pulp, for that is not always necessary; but that portion of it, especially, which is exposed. If this is adroitly done, with a *light*, steady hand, no subsequent inflammation is produced in the substance or cavity of the tooth. If there should be any marked sensitiveness in the tooth, inde-

pendent of the pulp, then the slightest touch of the cautery to it will prove effectual in completely removing it. In the large number of cases in which I have employed the galvano-cautery I have never seen or known any bad effects produced on the tooth. This result must be connected with the uniform care with which this nice operation has been done."

In whatever condition the tooth-pulp may be, the operation is attended with but very little pain. As the time of its application is but just a second or so, in the large majority of instances in which I have employed it, *there has been no pain whatever felt.* There may be a sort of twinge, which is but instantaneous. But whatever pain may arise is not to be compared to that from the process of extracting a tooth. Some of my patients have felt it so little while being applied, that they have asked me to apply it the second time, so as to make all certain that the nerve was killed.

If the cavity of the tooth so treated be minutely examined, a small black speck or spot can be seen after this cautery has been correctly and *successfully* used; this is the result of the carbonization of the pulp, and is a guide, to some extent, in the after process of removal of the carious portion of the tooth, which should always be done after the sensibility has been destroyed by the electric cautery. It is to be accomplished in the usual manner, with care, taking the precaution to leave none of the tooth that is decayed, as every particle of it should be removed, just as in any case of filling. For a few days afterwards, — sometimes only one, but generally two, — the cavity is allowed to remain only filled with a preparation of morphine and mastic, and after that the tooth is filled. In other cases I use camphor with mastic. But by this means I do accomplish what I believe no other dentist has done, and that is, to plug or fill the tooth cavity in the same sitting during which the pulp has been destroyed. This, however, depends upon the *complete absence of pain after the use of the electro-cautery.* I have already stated that there is always a little pain at the instant of cauterizing; but sometimes this at once disappears, and in such a case I do not hesitate to fill the teeth permanently. I also do this if there has been a little bleeding from

the cavity of the tooth subsequent to cauterization. It might be supposed that this procedure of stopping the teeth so immediately after the destruction of the nerve-pulp would be always followed by dull aching pain; but I am happy to say, that not the slightest indication of pain has in the great majority of instances ensued, in rather an extensive employment of this agent and method. As a *rule*, however, it is my opinion *the tooth should not be filled permanently on the same day that the electro-cautery has been applied*, unless in the instances just mentioned; that is, if the removal of the carious portion is not then being attended with sensibility. Experience and practice teach us to know the proper cases *which* can be filled at once or not.

I have found by experience, also, that by waiting a day or two, any sensibility remaining after the destruction of the dental pulp and excavation of the carious parts of the affected tooth is sure to disappear, assisted by the solution of morphia and mastic, or mastic and camphor, which temporarily occupies the cavity. By this time the cavity will bear the pressure of an instrument within it, and an examination will show that the destroyed pulp has receded considerably inward; the black spot is now so out of the way that the filling will not press upon it, or, if it does, it becomes a matter of the smallest possible importance, so far as my experience permits me to judge in this respect. I must here, however, warn others not to mistake the *black speck* here referred to for actual remaining caries.

Under the circumstances which have now been mentioned, the *results* of this operation are completely successful, and the teeth so treated are serviceable for years. If, however, tenderness of the tooth remain after the use of the cautery, it is always better to wait for its complete disappearance before proceeding to permanent filling. I cannot call to mind any single instance in which the pain was at all persistent after its use; but it will be sure to become so *if* the tooth is one not fairly suitable for preservation, from being either loose, or diseased at the apex or bottom of a fang, such as a small fungous growth, or some similar cause. In such cases, the destruction of the tooth-pulp,

accomplished no matter by what method, will prove unavail ing and unsatisfactory. Extraction finally being done in such instances proves the only resource. Should there be associated inflammation of the gums with a carious tooth, in which the pulp has been destroyed in the manner which I here recom mend, then the usual means for combating it must be resorted to, such as a leech or two applied to the gum, and repeated fomentations with warm water alone or warm milk and water bran or hop poultice. For pain in the tooth itself, the mor phine and mastic will be found quite sufficient."

*Lateral curvature of the spine* is of frequent occurrence in the youthful, and its results are serious. True curvature of the spine — *spinal disease* — is not curable by any sort of electric treat ment. But what constitutes actual *curvature of the spine* in the various directions? This, as yet an open question, must be an swered by consulting other authors on the subject, for our little space will not admit of the discussion. But I can state concisely and positively, that electricity *is useful* for a weak spine; for threatened, and for *apparent* lateral curvature, where the bones are as yet not altered by disease. In most cases, in the begin ning at least, from unilateral muscular debility, spinal curva ture is simulated, and if not remedied by support, rest, exercise and electricity, or other proper and timely means, doubtless will terminate in true lateral curvature. But all cases do not begin in this way.

*The treatment*, as regards electricity, in all suitable, hopeful cases for its use, is simply to be carried out on general principles. The large sponge electrodes, one in each hand of the operator, with a smart primary current first, and then a faradaic current, the body of the patient being in a straightened and easy pos ture, are to be applied and bathed over the region of the back, especially so, on the weak or *convex* side of the back and body, so as to make good electro-muscular contractions repeatedly, as in the loin muscles, in the *latissimus dorsi* and external oblique, in the lower portion of the trapezius, and the serratus, and inter nal oblique. Follow this with *mellowing* and deep-shampooing or dry grand-cupping. A supporting jacket, to be worn a part of the time, in some cases, is of the greatest assistance in the

cure. Cold sponge baths, air and exercise, with tonics, are also in the programme.

*Hydrocele.* — My experience here has been limited; but the few cases I have had occasion to treat by electro-therapeutics, have resulted favorably. One case was managed by applying the sponge electrodes, with some pressure, on the surface of the scrotum, using full bearable currents of electro-magnetism, and repeating it every day for one week, when the absorption was complete, and the case remains well. In two other cases I employed also the electro-puncture with the primary galvanic current. One of these was an old and ugly case — Mr. Kittredge, of Berkshire, aged forty-five, who presented in May last; a very large hydrocele of the left side, that had been repeatedly tapped and injected for radical cure; and although he suffered inflammation, yet the hydrocele was large and painful. It was fully the size of an infant's head, and appeared a formidable case.

This patient took the operating chair, which was swung to a very reclining posture, so that, indeed, his hips were higher than his feet or head; knees raised and widely separated. I then carefully plunged into either side of the scrotal sack two gold electro-puncture needles, taking care not to wound the testicle, — which, however, is usually well back out of the way, — and thus applied the constant current of galvanism from five to fifteen elements of Daniell's battery, reversing the current every minute, and continuing the *seance* for fifteen minutes. As does goitre, so did it visibly diminish in size during these fifteen or twenty minutes. This was repeated every other day, together with some induction currents to the surface of the scrotum to finish off with, for three *seances* more, at the end of which there was no water in the sac, but the left testicle hung lower than the right, and was still somewhat tender and painful. In a fortnight more, this soreness removed. It is now some eight months since he came to see me, and I learn that he remains perfectly well.

The other case, although not so apparently unfavorable at the beginning, was similarly and as thoroughly treated, but it is as yet but partially cured. In this case, however, there is evidently but little nervous power in the parts, for the penis is without

erection, and when the positive electrode is placed just back o the ischium and the other is pressed at the root of the peni there is but the slightest sensation from the strongest electr magnetic current, showing that the *pudic* nerve is all bu paralyzed.

For glandular enlargements, as well as for lymphatic tumor M. Boulu has, since 1853, been especially using electricity, an that, he says, with varied success. On the whole, he finds tha fine platinum needles for electrodes, plunged deeply into th mass of the tumor, and so leading the current through it work the best of all. He quotes a large list of cases and ex periences in this line, and his final opinion is, "that, for thes cases, the current is both chemical and exciting to the circula tion and absorbents, also producing a capability and tendency to contractility in the vessels and tissues about the affected parts that not a little, aid to wither the tumor."

My more extended and recent experience leads me to sa now, that electro-puncture is a suitable and often the only mod of treatment that promises a safe cure for hydrocele. My metho is, simply to insert two or four acu-puncture needles through th skin, the dartos and cremaster, into the bag containing th fluid. Thus let them rest. Now first apply the poles of th primary or secondary current, but very weak, to the needles o opposite sides of the scrotum, so that the current will travers the fluid. The current must not be so strong as to be painful Continue it for five or ten minutes, and at the same time appl pressure to the whole scrotum, and maintain it even after th needles are withdrawn. The pain from inserting the needles i scarcely felt, and the whole proceeding is simple, safe, and usuall successful. In a few hours after the operation, the swelling begin to diminish and to be less tense; the areolar tissue of the scrotu becomes gradually more and more infiltrated with the fluid whic had before distended the *tunica vaginalis*. In the course of a fe days, the infiltration diminishes, and totally disappears. If no within a week the operation should be repeated; and now, whil the needles remain, apply large sponge electrodes on each sid then above and below the scrotum, and thus pass as strong faradaic current as the patient can bear, for five or ten minut

more, all the while maintaining firm but graduated pressure, and the patient is often thus cured.

In one case, I passed sparks from the friction machine through the needles, and it was a success. But, on the whole, it seemed to excite and pain the patient more than the galvanic, or even the faradaic current. This might succeed better in some cold, phlegmatic cases, particularly if alternated with galvano-puncture, even where the faradaic current may have failed.

### *Urinary Bladder and Urethra.*

*Spermatorrhœa.* — I am quite certain, — and I speak advisedly, — that almost every case of this peculiar leakage can be saved from their sad condition, *if the principal cause (masturbation) is utterly abandoned;* if they are made so thoroughly aware of the danger and injury from such a debasing habit, as not only to quit it, but to apply themselves renewedly and devotedly to out-door work, or some other steady business, for all waking hours, and to mingle much in the society of virtuous women, or economize all their leisure hours in proper religious or intellectual pursuits. But if the causes, or any part of them, remain, — are not *absolutely* put out of the way, — all kinds of treatment and medication will prove a failure. Many young men lose their semen only during the act of self-excitation. The system, in a little time, becomes enfeebled, both intellectually and physically, the whole character of the individual is dwarfed, or changed for the worse, and the true objects of life become perverted. An impoverished personal character follows, and *is in degree* in proportion to the self-abuse; and not a few of these ultimately succumb to slight attacks of disease, while others find their way to our lunatic asylums, either as confirmed hypochondriacs, monomaniacs, or as disgusting oddities, or simple, imbecile idiots.

The causes are usually of two classes. First, some persons are naturally more prone to fall into this condition, under the same circumstances, than others, — for instance, the nervous and the lymphatic temperaments. The second cause is most fre-

quently "*masturbation;*" and the earlier this habit, the wor
the consequences. Idleness, or rather absence of systematic a
regular play, study, or work, so as to occupy *all waking hou*
or improper associations, allowing the mind to dwell on vulg
or lascivious stories, or pictures, are the bane of young boy
life. Habitually eating freely of raw apples in the latter pa
of the day is an exceeding provocative to spermatorrhœa, wi
dreams during sleep. A full bladder, constipation, hemorrhoi
or a long foul prepuce, may be a cause.

The diagnosis usually is not difficult, for the patient will infor
you; but, in some cases, a careful examination of the urine
the microscope is essential to positive and reliable diagnosis,
it is now known that sometimes the spermatic fluid takes a retr
grade course into the bladder, and thence is voided mixed wi
the urine. The prostatic fluid is often mistaken for semen; b
if the latter is under inspection, *spermatozoa* will be discovere

All the cases of this very peculiar nervous affection and morb
secretion may be arranged in two classes. The first are those
increased "physiological exuberance"—*an overflow of natu*
occurring once a week or so, and is usually almost harmle
For these, prescribe a cold sponge bath at bed time, early to b
and *early rising;* little food, and no fruit or nuts in the lat
part of the day. If any thing further, prescribe *formula* 2
12, 28 or 29, with or without a bottle of congress water eve
other morning.

The second class embrace all cases of *pathological sperm*
*torrhœa* and prostatic secretion, the result of a morbid mind a
habit, or of morbid functions, or from actual disease;—in eith
case, in effect, most disastrous and damaging, the more so t
longer it continues. The constitutional symptoms are, a gener
diminution or prostration of the nervous system, as shown
aversion to society, and to active exertions, nervousness, indig
tion, constipation, slouchy gait, clammy cold feet and han
dull pain in head and back, feebleness of memory, pallor of fa
dull eyes, little or no courage, no self-reliance, and a total wa
of youthful indomitable perseverance. But the *natural* consti
tion and temperament of each case must be borne in mind in
this investigation.

The local symptoms are the *emissions*, and a considerable pain or uneasiness in the region of the prostate, extending up to the *vesiculæ seminales*, and a frequent desire to pass the urine. If we commence active treatment, in addition to what we advised for the first class, lay the patient upon his back, and introduce a large-sized *insulated steel sound*, as a number 7 or 9, and the colder it is the better; though oiled, it will be fearfully dreaded by the patient at first, and will probably meet with spasms of the urethra, simulating stricture. When the instrument is passing the seminal ducts, and the prostatic portion of the urethra, (if ever so gently and skilfully,) the sensation is very disagreeable the first few times, but rapidly grows less and less, if the operator is skilful and patient, using no force, and yet always succeeding in passing through the prostate. The negative sponge electrode should be already adjusted at the perinæum, while the tip of the negative conductor, from one galvanic cell, is held in contact with the insulated sound for ten minutes, — is all that is required. This should not be repeated more than every other day, or once or twice a week. Thus have I cured cases in the course of a few weeks or months.

*Strictures of the Urethra.* — I have treated, by galvanism and faradaism, quite a large number of cases of soft and spasmodic strictures of the urethra, and in not a single case have I failed to benefit or cure the patient. True, I have been careful in selecting my cases. All bad cases of very *hard strictures*, have at once been referred to my nearest neighbor, Dr. J. Mason Warren, or to the Massachusetts General Hospital, for surgical operation.

For this purpose, we should have neatly *insulated silver, and zinc catheters*, and insulated steel sounds, of different sizes. I keep ready for use a case of assorted sizes of steel sounds, *perfectly insulated* with fire-japan, excepting an inch or less of the tips. Some are of the ordinary, blunt shape; others are ball tipped, with narrow necks, prepared for me by Messrs. Codman and Shurtleff, 13 Tremont Street.

The catheter, or sound, thus insulated, is introduced into the urethra, so that it rests against the stricture. No force is called for, but patience. The positive pole (a sponge electrode) is

now first adjusted at the coccyx, or perinæum; the patient lyi
easily, and arranged so that the current can be maintained for
quarter or half an hour, if necessary, the negative pole, wi
very weak current to begin with, is placed in contact with t
sound or catheter that is in the urethra. The primary curre
of five or ten cups, (Daniell's battery,) is my first choice. B
the extra, or electro-magnetic current, will do, observing t
same rules. The current must be weak, and *not painful*, at lea
to commence with. No great, no more pressure is to be use
than the gentle manipulation (every few minutes repeate
that succeeds to introduce the instrument where there is
stricture. Very soon the instrument glides along down, almo
of itself, into the bladder. Draw it back immediately, and reta
it a little longer at the point of stricture, and also let it rest a fe
minutes, or so, at the prostate, even if it is not the seat of strictur
Always plan by patience and perseverance to succeed each tim
This operation may be repeated every two or three days, or on
a week.

The *bladder* is readily affected, through its nerves, by mea
of electricity. Our own experience is confirmed, moreover,
recent researches and experiments of Professor Budge, who,
the application of galvanism to the medulla oblongata, in vario
animals belonging to the class of mammalia, shows that contract
and other movements of the bladder can be produced at wi
It thus appears that there is a special tract of nervous substan
which, commencing in the cerebral peduncles, and runni
downwards through the corpora restiformia, medulla oblonga
and anterior columns of the spinal cord to its very extremi
possesses the power of inducing contractions and various mo
ments in the bladder; and the motor fibres for this tract iss
from the anterior roots of the third and fourth sacral nerves, a
proceed to the bladder.

A reflex motor impression may be seen, propagated to t
bladder, by irritation applied to the sensory fibres, entering t
posterior roots of the first, second, third, and fourth sac
nerves. That portion of the spinal cord which is opposite t
lower lumbar vertebræ includes a nervous centre, the irritati
of which is constantly followed by wavy, contractile moveme

of the bladder; and the bladder excitability from this centre is more persistent than that from any other part of the spinal cord.

*Paralysis of the Urinary Bladder — Dysuria — Incontinence of Urine.* — Thus it appears that there may be diminished or lost nerve power of, and about, the bladder, resulting in very different symptoms, termed diseases. In true palsy, partial or complete, situated in the muscular coat of the bladder, there is *dysuria;* which must be known as not strangury from stricture (or from spasm) of the urethra. In this latter case, the water comes drop by drop; in the former none, or only by the greatest efforts, and with pain. For palsy of the bladder, electricity may be applied directly within the organ and to all its sides. The bladder, rectum, uterus, and other organs, having only ganglionic nerves, are but very slightly sensitive to electricity in health, or in palsy, but highly so when these parts suffer from inflammation, or neuralgia. This has also a grand diagnostic importance.

*For electrifying* the bladder, we employ the *insulated* catheter, or sound, first inserted into the bladder, while a large sponge electrode (*positive*) is adjusted on the sacrum; then, while the current is running at good strength, touch the tip of the negative conductor to the outer end of the catheter, and if the patient can bear it, move gently the catheter-electrode about, inside the bladder, for ten or fifteen minutes, or until a painful contraction sets in, when the current must be diminished, or repeated only for a few seconds, with as many for recess, or stopped altogether. Finish the seance by faradaizing the lower portion of the abdomen, not only for the reflex influence, but in many cases of weak bladder there is also lost tone in the abdominal muscles. In such a case, the urine is forcibly expelled as soon as a catheter is introduced; and we have only to faradaize the abdominal muscles to produce a cure. In other cases, there is loss of functional sensibility, in the mucous, muscular, or other tunics of the viscus, so that the urine accumulates without the patient being conscious of it, until, from long over-distention, there is actual palsy of the bladder. For this reason, to restore this early loss of bladder sensibility, and to aid the reëstablishment

of the reflex power of the will, which will cure the difficult; the applications of electricity must be directly to the intern coat of the bladder.

*Incontinence (or loss of power to hold the urine) from paral sis of the sphincter*, or neck of the bladder, requires a diffe ent procedure. Here the urethral electrode (for male or f female) is to be introduced, as usual, into the bladder, b with the precaution of observing the point and instant of entran of that viscus,—which is known by the movement of the cathete electrode; also by the sudden appearance of urine through t instrument,—when the electrode is to be withdrawn a litt until the metallic tip rests just at the sphincter of the bladde then, with the other electrode on the perinæum, or rather mov over the parts corresponding with the levator ani, the curre can be let on pretty strongly. This may be repeated daily.

Attempts have been repeatedly made to harmlessly dissol *calculi* in the living urinary bladder. The first attempt appea to have been by Dr. Harle, of Norwich, England; but the fir report of actual treatment for this by electricity is by M Provost and Dumas. These trials were with a view to destro ing their state of aggregation; for if the molecules of the c culi become friable, they would wash out. But after expe ments on dead men, and on living dogs, and becoming satisfi that their method was to a degree susceptible of applicatio they perceived that it can present no advantage for the remov of calculi that are not saline compounds, such as, for examp the alkaline phosphates. It is therefore necessary beforeha to be satisfied as to the *nature* of the calculi in the case, even otherwise feasible. By a series of elegant experiments by Bonnet, surgeon-in-chief of the Hotel Dieu at Lyons, he h shown in a satisfactory manner that electric currents have t power to *convey* acids or alkalies *to* the urinary calculi by t electro-chemical decomposition of a saline solution that b been previously thrown into the bladder, as when using t solution of nitrate of potassium, instead of simple water, wi out the powerful reagents being diffused in the urine that contained in the bladder.

Dr. Bence Jones pursued these researches by means of

steady galvanic stream, and concludes that the solution of nitrate of potash is for most cases, and on the whole, the most harmless to the viscus, and most active for the dissolving process. Calculi of the oxalate of lime are the only ones that have resisted this action, and these, if they contain phosphates also, are slaked down, but if they contain the urates, or uric acid, then they are slow to yield.

Notwithstanding all this, but few fair attempts have actually been made to dissolve renal calculi from the bladder in the living human patient. The results, on the whole, so far, I conceive, are negative; although it has been claimed by Dr. Melicher and others, as we are aware, to have been successfully accomplished. The calculi are probably only affected *secondarily*, even by the improved process, while the current is separating the nitric acid, and driving it to one pole, and the potash is hurried off to the other. Nor can the bladder play the part of an electric bath tub for such chemical power, without receiving some doubtful effects.

Dr. Simon has recently treated some cases of *incontinence of urine* in children by means of galvanism, the current being conveyed by the aid of a partly insulated catheter into the bladder. The result in two or three marked cases, he says, has been quite successful. The cases selected for this treatment, of course, are those of true *incontinence of urine* from *atony*, and not from irritable bladder, or from kidney or other urinary diseases.

A clear and practical distinction can and should always be made between the paralysis of the neck of the bladder and that form of paralysis that affects the body of that organ; the first form being attended with *incontinence* of urine, the second with *retention* of urine. But we hardly believe that this important difference is clearly attended to by very many practitioners.

According to Dr. Gross, of Philadelphia, and Professor of Surgery in the University of Louisville, *irritability* and *neuralgia* of the bladder have many points in common; indeed, few authors devote a distinct chapter to the latter affection. Neuralgic affections of this viscus, in our country at least, certainly seem very common; and according to Professor Gross, we

may usually find neuralgic symptoms at the same time in other parts of the patient. Sometimes the pain is located in one spot; at other times it extends to other organs. There is in these cases a frequent desire to pass water, and the urine is thrown out in jets, and in very small quantity, while a distressing soreness is left behind in the urinary passages. A systematic course of laxatives, together with morphia, or belladonna, or conium, seems usually beneficial; but the electric *positive* pole, directed *precisely* to the part affected, while the other pole is at a distance, and a gentle current is thus circulated for five or ten minutes, will all the better quell the neuralgia at this site.

But where the bladder is rather affected with *atony* or *paralysis*, instead of irritability or neuralgia, then the electric current must circulate in the opposite direction *mainly*, that is, to suddenly *reverse* the current, and make it for one minute this way, or *direct*, and but a quarter of a minute reversed.

In managing the various forms of paralysis of the urinary bladder, I cannot but urge the precaution laid down by Dr. Gross; and that is, where the accumulation of water is large, or has long existed, to never evacuate the whole of the urine at once, as he says he has seen several patients die from the severe depression induced by the *sudden* removal of the accumulation from such an over-distended bladder. In all such instances, he advises to allow a small quantity of urine to remain, and to apply a bandage to the abdomen, as after tapping or parturition; to give castor oil and turpentine cathartics, together with strychnine and tinct. cantharides.

*Incontinence of urine* may often be observed in patients who have had rheumatism. In most of these cases, the affection has been referred to some deviation in the spinal marrow. But Dr. Froriel denies this, — as any affection of the lower portion of the cord, which would cause paralysis of the bladder, would at the same time produce some paralytic symptoms on the voluntary muscles of the lower extremities. It is therefore referable rather to a local affection of the bladder itself — to some deranged state of *its* nerves, of its muscular fibre, or of both. Taking this view of the malady, he resolved to try the effects of the local

application of electricity; using a metallic stylet, insulated and terminating in a button-like point, which he introduced into the bladder: this he does with the aid of a gum-elastic catheter, that covers the whole except the button point. The handle of the stylet is then connected with one of the wires of an electro-magnetic machine, while the electrode of the other conductor is pressed against the pubes. Thus the induction current of electricity is passed through the bladder for a quarter of an hour each day. The result is, he says, that generally the bladder retains its urine better from the very first day after the application of electricity. But this should be repeated at intervals, until the bladder recovers its full power. He reports several cases of this trouble in persons from thirty to forty years of age, in whom the affection was completely removed by means of this form and method of using electricity.

Electricity is found equally capable of removing the weakness on which the enuresis of children depends. In some cases one such application of electricity removes the disease. In others it requires to be repeated at intervals. It is found that, in some weakly children, a few doses of iron confirm the cure. In connection with the electrical treatment, I usually prescribe in such cases one drachm of the muriated tincture of iron to seven drachms of simple sirup, to give the child a tea-spoonful at every meal.

*Albuminaria.* — Albumen in the urine is only a symptom, but a significant one, pointing to disease in the kidneys. We occasionally are called to see children, and young persons, who are seized with fits, convulsions, epileptiform perhaps, which recur more or less frequently, but cannot be accounted for by indigestion, or dentition, nor by the invasion of any inflammatory or eruptive disease. Nor is there any sufficient evidence of cord or brain disease; but if there is anasarca, we may suspect, and if the urine is examined, we may *find*, many of these cases arising from, or attended with, albuminous urine, and the treatment should be to this indication. On a careful examination of the urine, no albumen may be found; and the absence of albumen makes it in the highest degree probable that there is no structural

disease of the kidneys; as the absence, by test, of sugar in the urine, proves the non-existence of diabetes.

Some of these cases are at first taken with severe epigastric pain, finally ending in insensibility and death. Others are attacked with more or less epigastric or abdominal pain, fits, and anasarca. Some of them will early show a swelling of the face and eyelids, but more frequently there will be only the epigastric uneasiness, or distress, with convulsive fits, and biting the tongue. Prescribe *formula* 28; but there is little hope of success at this late stage of the disease.

*Test of Urine.* — When testing for albumen in urine, we find in some specimens, that adding nitric acid produces a cloudiness of some acid urate, quite without albumen. Dr. Beals says the former may be distinguished from the latter, either by boiling, which dissipates the urate, or by the microscope, which reveals crystals of uric acid in it. Or, if the test-tube containing the urine be held in an inclined position, and the acid allowed to trickle, a few drops at a time, down its lower side, the heavier acid liquid will sink through the urine, and form a distinct layer at the bottom of the tube. Now, if albumen be present, a cloudy zone will appear *immediately above and in contact with the top of the nitric acid, and bottom of the urine.* But, if no albumen exists in it, but an excess of urates, a cloud will appear *at the top surface of the urine*, while the lower part will remain perfectly clear where it is in contact with the nitric acid.

When heat is applied to a sample of urine, or nitric acid is added, if there appears only a milkiness or opalescence, it is an evidence of very small quantity of albumen; if, with this result, the urine be *uniformly* pale, and proves of only a low specific gravity, say 1005 to 1010, we should suspect organic disease that is chronic and incurable.

*Symptoms of excessive urinary acidity* are forced upon our notice, and call for remedial aid, only when the skin, or the mucous membrane, has become quite irritable by the prolonged action of the acid state. The amount of local or general uneasiness or pain will vary with the sensitiveness of the temperament, and the degree of acidity; but the outbursts of an over-acid state are made manifest by an itching, nettle-rash, herpes, or

eczema. It may thus constitute a part of the nervous or neuralgic malady.

The best diet for excessive urinary acidity is exactly the same as that for diabetes. Saccharine and farinaceous diet give rise to various acids, and therefore should be avoided. If fatty substances, as cream, butter, fat, or oil, be taken by such patients, there is produced uneasiness in the stomach, and heartburn. The types of sugar and butter must, therefore, be avoided. In extreme cases, limit the patient to small quantities of tender, lean animal food, such as fish, flesh, fowl, or game and eggs, with brandy largely diluted with water. If there are attacks of stomach acidity, give quickly emetics of ipecac and warm water, and so break them up. The cure can be absolute if the treatment is rigid and persevering.

*The mineral-acid treatment*, for the cure of the uric or oxalic acid diathesis, for many of these classes of patients, is very important, as a part of a rational treatment. From the teachings of Dr. H. Bunce Jones we learn that, —

*a. Hydrochloric acid* is more especially the acid of the natural gastric juice; and it seems reasonable that it should be prescribed, more particularly when there is feeble digestive power; as after long illness, when animal food begins again to agree. It should be taken, dilute, just before each meal of animal food, *for digestion.*

*b. Nitric acid*, generally, may be considered *to promote secretion*, and perhaps oxidation; and, with this view, it should be taken dilute, so as to be absorbed before the food enters into the stomach. It should be taken one or two hours before meals, on an empty stomach.

*c. Sulphuric acid* is regarded as an astringent, *to stop* perspiration, hemorrhage, and diarrhœa. It may be, therefore, regarded almost the opposite of nitric acid in its action on the system. It should be given, dilute, in time for absorption before food is taken, an hour or so at least. Thus, then, when rightly used, hydrochloric acid promotes *digestion;* nitric acid promotes *secretion;* sulphuric acid produces *constriction.*

### *Rectum.*

*Prolapsus ani*, as also *incontinence of the fæces*, either in adults or children, is usually owing to palsy, or to a relaxation of the sphincters of the anus from loss of nervous tone, and is usually recovered from by the use of electricity. One electrode (negative) is to be introduced within the sphincter ani, while the other, a large moist sponge, (positive,) is placed at or moved about the perinæum, and also moved over the levator ani muscles. The seance should be according to its effectiveness — from ten to fifteen minutes, and repeated daily, or every other day, with all the current the patient can bear. At the same time, prescribe *formulæ* 6 and 11, or 9 and 10, or 20.

*Prolapsus of the rectum in children*, where the foregoing and other methods fail, may be more surely cured by the following: In adults, the excision of some of the superfluous anal folds, or of a portion of the prolapsed mucous membrane, is often necessary and successful. But in children, the galvanic cautery is the most manageable and the most successful. By aid of Grenet's battery, in good working order, and at full strength, I burn three or four places close within the orifice, each the size of a three-cent piece, and pretty thoroughly, so as to reach the sphincter muscle. Return the prolapsed mass immediately, by temporarily elevating the hips higher than the shoulders, at the same time compressing the protruded portions with a soft sponge or cloth, wet in very cold water. When returned, apply cold-water dressing over the anus. This will usually complete the cure. In some cases the operation has to be repeated.

Dr. Dolbear reports two cases of *prolapsus ani* which, after various unavailing treatments, were finally cured by the sub-cutaneous injection of the sulphate of strychnia. The first case was that of a child, four years old, who had suffered from prolapsus for nearly two years. He injected the thirtieth part of a grain, by means of the sub-cutaneous syringe, at a short distance outside the anal orifice. It did not cause much pain, and

the child was in a few minutes as lively as usual. The prolapsus returned, however, and another injection was practised, after which there was no return of this weakness.

Another case was that of a boy, five years old, who had prolapsus ani, for which ice, astringents, cold and hot baths, and injections, and *finally* "electricity had been prescribed without success." No description of the *method* is given; it is only stated that electricity failed. It was, therefore, determined to try the hypodermic injection of sulphate of strychnia. A small puncture was made close to the anal orifice, and the canula was inserted a little way into the puncture, and *eleven drops* of the solution (thirty centigrammes of the sulphate to thirty grammes of water) were injected, and the puncture was then compressed, for a few seconds, to prevent the escape of the solution. The child did not suffer pain, and there was no return of the prolapsus ani.

*Polypus in the rectum* is a rare, but a troublesome disease when it does occur, and is usually found in children under a dozen years of age. Dr. H. F. Damon, of this city, read a most interesting paper on this subject, before the Suffolk District Medical Society, last fall. Since that time I have had two cases, both of which came to me as obstinate cases of piles, or bowel trouble, that resisted all treatment. One case will illustrate.

*Case.* — A little boy, six years of age, was brought by his mother, who herself had long before been under galvanic treatment by me for a shoulder difficulty. He had been long treated for chronic diarrhœa. For the past year, he had, by times, lost considerable fresh blood with stool; for he said he had to strain very hard to have any thing pass. He complained of some soreness at his "set-down," which led to investigation with the rectal speculum. More than thirty polypi were found, from the size of a pea to those of good-sized cherries, of a strawberry color; and two of a darker color, hard and slippery, like fresh cherry stones when pressed between the fingers.

These numerous *polypi* could never be removed by the knife, for the hemorrhage would be fatal. If there was but one or so,

it might be removed by ligature or torsion
numerous, that, from a few lines within the
some three or four inches, the rectum was
had recourse to the *galvanic cautery*, by aid
battery, with bellows. Each of the *polypi*
pedicle, which was severed only by means o
side-slit in the rectal speculum was retained
until all that presented were entirely remo
tated a little, to present a new field and cro
seized by a pair of long-handled bullet forc
the platinum point for cautery was adjusted
and the severance was done instantly, as o
without pain, and without a drop of blood
was cleared at two sittings. It is now over
amination shows only a hard point, as an es
situated. Both cases are perfect cures.

*When electrifying the uterus*, it must be
*in health*, the uterus, the cervix, and all the
vagina, have very little sensitiveness to t
This must always put us on our guard.
uterus, on the contrary, is far more sens
flamed, congested, ulcerated, or neuralgic
sensitive to the electric current. The l
vagina, and the external portion of the fe
health, are exquisitely sensitive and painf
action of electricity, and this must always b

*The Galvanic Suppository.* — For troubl
pation, more frequently, but sometimes for a
the urethra, vagina, or bladder, this instru
the rectum, and allowed to remain there fo
at a time, according to the effects produ
desired. This galvanic instrument is ma
form of a female syringe tube; i. e., three or
a swell at its inner third three quarters of
and a narrowness at its shoulder of a quart
an inch, so as to remain easily adjusted.

similar metals, as zinc and copper, or zinc and silver, in equal transverse or longitudinal halves, and so put together that the tip is zinc, to lie in the intestine, while the shoulder or shank is silver, to lie easily in the sphincter. Or, where required, the division is lengthwise, and the lateral halves are made of the respective metals. In order to be truly effective, the halves must be fairly insulated, as to each other, by a slip of ivory, or hard rubber; the metals must be clean, and the insertion must be effected without using oil, or any kind of grease. By wetting the anus with warm lather water, the instrument is easily and effectively adjusted.

For chronic inertia of the womb, for a patulous and relaxed state of the cervix, and for atony and prolapsus of the vaginal walls, this instrument may be employed to great advantage *in the female vagina.* In these cases, however, it is better that the instrument should be double the size above described, and having the upper half pure zinc; the lower half may be of copper, or yellow metal, *fine silver plated.* Thus it is a very tolerable instrument, easily endured in those delicate parts. It should be bright and clean, and inserted without oil or grease, and the uterus should be lifted by it as far as it will readily go, and secured by a perinæum bandage, or the monthly cloth.

*Steel or iron* lost in a flesh wound can be discovered by electricity and magnetism. Steel or iron, we all know, becomes *magnetic* when placed under the influence of a *galvanic* current or permanent magnet, and, when thus magnetized, it in turn attracts or repels other pieces of steel which are not magnetized; but still more sensibly does it affect a delicate magnetic needle. So that, where a nail or needle has accidentally wounded the flesh, and broken off so as to leave a piece that cannot be readily discovered, hold a pocket compass near to the wound and move it gently by it, observing the action of the compass needle. If it is not thus affected, obtain a large and powerful horse-shoe magnet, and place its ends close to the wound for an hour or so; then try it again. If it is not discovered, pass a strong *galvanic* current through the flesh steadily in one given direction for a

quarter or half hour, then test it again with the compass. If no compass is at hand, suspend a little sewing needle by a fibre of silk, fine cotton, or hair, and swing it carefully by the wound, and watch for the attraction or repulsion. Repeat it until the demonstration is complete. The author could report several very interesting cases here where these delicate means proved perfectly reliable witnesses and a success.

*The electric probe*, for discovering the lodgement of a ball, or other metallic body, within a wound, in difficult cases, is, for the surgeon, practical and reliable. Professor Favre, of Marseilles, France, first proposed "*the galvanic probe*" for this purpose. All that is necessary, in the most difficult case, is a single galvanic cell, or cup, and an astatic needle, or a galvanometer, and the double insulated probe. This latter, the double electrode probe, may be made simply of two ordinary silver probes, bound together, side by side, with a slip of rubber or gutta-percha between, so as to be well insulated from each other, and being well wound and varnished with asphaltum their whole length, excepting the sharp points at one end, and the ball tips at the other. This probe could thus be flexible, and the sharp points could be made to prick the ball, or, at least, to make very sure metallic contact, and so surely close the circuit of the battery, if a ball or any metal substance is found.

This is a very simple operation, that may be performed by any dexterous physician if he has only an electro-magnetic machine, the prepared probe, and a pocket compass. A galvanometer would be better, but a good magnetic needle will do, as I have often used it, and find it quite reliable. First, set the battery to work; not the helix, but only the pair in solution. Then insert the probe into the wound near the supposed site of the ball; then let an assistant make sure contact at the outer *ends* of the probe, with the two wire conductors that usually lead to the helix of the machine, and so, in case it hits the ball, close the galvanic circuit. This will be shown by the sudden and decided deflection of the magnetic needle, which should be held all the while close *under* or *over* the wire conductor. This test is perfectly reliable.

MEDICAL STUDENTS: Our investigations in this so intensely interesting field of medical lore, must now draw to a close. Let us here congratulate ourselves, and thank God "for this day and opportunity" of seeing *understandingly* so much of this *new phase* of our noble art. I said to you in the Preface, that we were rich in the material for a systematic work of this kind, and now can say again, that we feel still burdened with the untold matter that so interests ourselves, and which we desire you should know. But the original bounds of this work are already far exceeded; I therefore will only remind you, with a parting emphasis, of the beautiful aphorism of Dr. Althaus, (who, by the way, has written well on this subject,) that "it is not electricity that cures diseases, *but the physician*, who may cure disease *by means* of electricity." In a word, it is the *method* and *skill* directing this agent, that give the success. So we see, after all these complicated researches and perplexing questions, how very plain and straightforward are the results, so far as we have mastered them. Hence we are taught, that simplicity is not only the ultimate aim of all science, but the very consummation of all art.

Finally, as medical men, we are *to watch* carefully for opportunities where we may aid Nature in her conflicts. We are to know where, when, and how to calm and tone the fretted nerves, and where and how to arouse from the insidious and fatal-tending effects of vaso-motor palsy. The practice of medicine will not admit of tardiness nor carelessness; nor must we work by sheer force, and go blindly on, for thus, on the one hand, we may do infinite harm by a meddling interference, while on the other, ours is the opportunity of the good Samaritan; and often and again by our timely help, judiciously given, we may, for our confiding patient, *turn the scale of life* — from weakness, from pain, from palsy, and from death.

# APPENDIX OF FOR

☞ For Appendix of *Rules*, see Chapter V., p. 4

**1.**

℞ Potassii Bromidum, ℥ ss.
Tinct. Cort. Aurantii, ℥ j.
Syr. Zingiberis, ℥ j.
Aquæ puræ, ℥ vj.
M.

*Dose.* — A table-spoonful, or less, at bedtime, (or three times a day,) for *insomnia* and nervousness.

**2.**

℞ Potassii Bromidum, ℥ j.
Tart. Antimo., Gr. xx.
Morphine, Gr. v.
Aquæ Cinnam., ℥ vij.
M.

*Dose.* — A tea-spoonful *dilute*, at bedtime, or more dilute and taken in broken doses during the twenty-four hours.

**3.**

℞ Quiniæ Sulph., Gr. xx.
Ext. Sem. Colchici, Gr. viij.
Ext. Digitalis, Gr. jv.
M.

Divide into *ten* pills. Give *one* every eight or twelve hours, for two, three, or four days, in *sub-acute* rheumatism, gout, or neuralgia.

℞ Acidum
Pulv. Al
Pulv. Rh
Pulv. Op

Divide into
one pill after

℞ Ext. Con
Morphin
Quinine,
Pulv. Al

Divide into
at night, or
neuralgic pai

℞ Strychni
Acid Nit
Aquæ pu

Each *drop*
To a child of t
an adult, ten,
dilute, *once*, t

7.

℞ Hydrarg. Biniodidum, Gr. ij.
Potassii Iodidum, Gr. x.
Morphine, Gr. ij.
Ext. Conium, ℈ij.

Divide into *twenty-four* pills. One a dose; once, twice, or thrice a day, for scrofulous rheumatism, neuralgia, and central palsy; to be continued from one to six or eight weeks, if necessary.

8.

℞ Tinct. Iodine comp., ʒ vj.
Hydrargyri Bichloridi, Gr. v.
Aquæ puræ, ℥ vj.
M.

*Signa.—For a Lotion.* A cloth wet with this, and applied to *painful nodes* and swelled joints,—scrofulous, syphilitic, or *old* rheumatic; cover with oil-silk, and keep on all night, and if necessary repeat for weeks.

9.

℞ Pulvis Capsici,
Ferri Sulph., āā, ʒ ss.
Quinine Sulph., ʒ j.
Ext. Gentianæ, ʒ ss.

Divide into *sixty* pills. *One* a dose, once, twice, or thrice a day.

10.

℞ Pulv. Ipecacuanha, ʒ ss.
Quinine, ʒ j.
Strychnine, Gr. ij.
Pulv. Aloës, ʒ ss.

Divide into *sixty* pills. *One* a dose, once, twice, or thrice a day.

11.

℞ Plumbi Acetas, ʒ ss.
Aquæ puræ, ℥ viij.
M.

*Signa.—For a Lotion.*

12.

℞ Ext. Belladonnæ, Gr. xv.
Ext. Hyoscyamus, ʒ i.
Quinine, ʒ ss.
Morphine, Gr. jv.
Tart. Antimo., Gr. x.

Divide into *thirty* pills. *One* at night; also, if necessary, one in the morning, in cases of headache or neuralgia.

13.

℞ Potassii Iodidum, ℥ ss.
Aquæ puræ, ℥ viij.
M.

*Dose.*—A tea-spoonful *dilute* in water; taken two, three, or four times in the day.

14.

℞ Iodide Potassium, ʒ ij.
Iodine, Gr. xij.
Aquæ puræ, ℥ jv.
M.

*Signa.—For a Lotion.* Wet a cloth, and envelop the joint for the night, or three or four times in the twenty-four hours.

15.

℞ Hydrarg. Bichlor. Gr. ij.
Aquæ Calcis, ℥ ij.
M.

"*The Yellow Wash.*"—A lotion for obstinate cutaneous eruptions, tumefactions, or fissures; as sometimes about the anus.

**16.**

℞ Tinct. cimicifuga race.,
Tinct. Valerian fortis,
Tinct. Actæ Racemosa,
Syrupi, f ää ʒ j.
Morphine, Gr. jv.
M.

*Dose.* — A tea-spoonful every four or six hours, until relief, in acute neuralgia or rheumatism; and then continue once or twice a day.

**17.**

℞ Pulv. Guaiaci Resinæ,
Sulphuris Sublim.,
Potassæ Bitartras, ää ʒ ss.
Treacle, (*molasses,*) ʒ iij.

*Mix* in a teacup; stir afresh every time, and take a tea-spoonful four times a day in old sciatica; or once a day, or every other day, for constipation and piles.

**18.**

℞ Oleum Terebinth., ʒ j.
Sodæ Bicarb., ʒ j.
Syrupi Acaciæ, ʒ ij.
Aquæ calcis fortis, ʒ iij.
M.

*Shake the vial afresh every time,* and give a table-spoonful, one, two, three, or four times a day, in obstinate chronic neuralgia, sciatica, &c.

**19.**

℞ Tinct. Cinchonæ, ʒ v.
Liq. Potassæ Arsenit., ʒ v.
M.

*Dose.* — A tea-spoonful after meals, once, twice, or thrice a day.

**20.**

℞ Tinct. Cinchonæ Comp., ʒ vj.
Quiniæ Sulph., ʒ ss.
Elixir Vit. Aromat., ʒ j.
M

*Dose.* — A tea-spoonful or two i the morning; in some cases at ever meal.

**21.**

℞ Fluid Ext. Sennæ, ʒ iij.
Fluid Ext. Rhei, ʒ ij.
Syr. Zingiberis, ʒ j.
M

*Dose.* — One or two tea-spoonfuls or more, as a *laxative.*

**22.**

℞ Tinct. Guaiaci Ammo. ʒ ij.
Tinct. Aloës et Myrrhæ, ʒ iij.
Treacle, (*molasses,*) ʒ iij.
M

*Dose.* — A table-spoonful, (or hal of that,) and repeated every few hours or less often, in dysmenorrhœa, consti pation, chlorosis, or neuralgic rheu matism of the uterus.

**23.**

℞ Argenti Nit., Gr. x.
Morphine, Gr. v.
Ext. Hyoscyamus, ʒ j.

Divide into *forty* pills. Give *one* a meal-time, once, twice, or thrice a day for only twenty or thirty days. Afte omitting twenty days, if necessary, i may be repeated again and again.

**24.**

℞ Potassæ Nitratis, ℥ j.
Potassii Iodidum, ℥ ss.
Aquæ puræ, Oj.
M.

*Dose.* — A tea or table-spoonful *after* one or more meals, daily, in chronic bronchitis, or atonic *dyspepsia*; also where *asthma* is complicated with either.

**25.**

℞ Fluid Ext. Aconite, ℥ ij.

*Signa.* — *For a Lotion.* In asthenic cases of neuralgia and local paralysis. Wet a cloth, lay it on, and cover all with oil-silk.

**26.**

℞ Fluid Ext. Arnica, ℥ ij.

*Signa.*—*For a Lotion.* In sthenic cases of neuralgia, debility, and local palsy. Wet a cloth, lay it on, and cover all with oil-silk.

**27.**

℞ Biborate of Soda, ℥ j.
Morphine, Gr. v.
Aquæ Rosæ, ℥ ss.
Oleum Olivæ, ℥ j.
M.

*Signa.* — *For a Lotion.* To be applied over and about the eyelids, in irritable or neuralgic eyes; and within the external meatus, by camel's-hair brush, in irritative diseases of the ear.

**28.**

℞ Sesqui Carb. Ammonii, ℥ j.
Acidi Citrici, ℥ j.
Aquæ Camphoræ, ℥ vj.
M.

*Dose.* — A table-spoonful, in irritable bladder and albuminaria; and as palliative in Bright's disease.

**29.**

℞ Tinct. Ferri Chloridi, ℥ j.
Tinct. Digitalis,
Tinct. Nux Vomica, ää, ℥ ss.
Aquæ Camphoræ, ℥ vj.
M.

*Dose.* — Two tea-spoonfuls, two, three, or four times a day, in feeble heart-movements, and ganglionic debility.

**30.**

℞ Sulphite of Potassium,
(*vel*) Sodæ, ℥ j.
Aquæ, Oj.
M.

*Signa.* — *For a Lotion.* Sponge the whole person over with it at bed-time, or after bath, and dry in with the hand, as in lead poison and wasting palsy.

**31.**

℞ Strychnine, Gr. ij.
Acidi Acetici, gtt. j.
Aquæ destillatæ, ℥ j.
M.

*For Hypodermic Injection.* — Of this, five, ten, or twenty drops may be injected into the most palsied muscle, or part, and repeated daily until effect.

**32.**

℞ Morphiæ acet., Gr. x.
Aquæ Destillatæ, ʒ j.
M.

*For Hypodermic Injection.* — Inject fifteen drops, more or less. It is about double the strength of laudanum.

**33.**

℞ Atrophine, Gr. iij.
Aquæ Destillatæ, ʒ j.
M.

*For Hypodermic Injection.* — Inject ten to twenty drops into the most painful spot, or protractedly-spasmed muscle.

**34.**

℞ Cyanuret Potass., ʒ j.
Aquæ, f. ʒ vj.
M.

*Signa.* — *For a Lotion.* Wet a single thickness of old cotton cloth, and cover the tumor or joint, without much other covering, and without oil-silk. It is often well to alternate this with *formula* 35; the one for the day, the other for the night.

**35.**

℞ Plumbi Acetas, ʒ j.
Aquæ, f. ʒ vj.
M.

*Signa.* — *For a Lotion.* Wet a single thickness, and wrap the joint in it, and for several hours repeat the moisture, with little or no cover; for coolness, in *hot* rheumatic or scrofulous joints.

**36.**

℞ Tinct. Aconite fortis, ʒ j.
Adipis, ʒ ij.
Chloroform, ʒ j.
Morphine, Gr. xx.

Mix in a mortar, and put into wide-mouth glass-stopped vial. Apply, by spreading a little on the sk over the seat of pain, and quick covering with a cloth and oil-silk, f chronic muscular pains.

**37.**

℞ Liq. Ferri Persulphas, ʒ ss.
Cerate Simplex, ʒ j.
M

Apply the size of a pea, daily, f piles, *where chronic and with debility* also for ulcerated hemorrhoids.

**38.**

℞ Liq. Ferri Pernitratis, ʒ ij.
Syrupi, et Brandy, āā, ʒ j.
M

*Dose.* — A tea-spoonful after meal in *chronic atonic diarrhœa*, and in ne vous debility with irritability.

**39.**

℞ Pow'd. Cantharides, ʒ ss.
Ext. Hyoscyamus, ʒ j.
Oleum Olivæ, gtt. x.

Make thirty pills. One a dose, t be taken once a day.

**40.**

℞ Emplastri Belladonnai.

Four by six, or six by ten inches.

# INDEX.


Abdomen, affections of, 961, 963.
Abdomen, to electrify, 963, 466–469.
Abdominal muscles, 302.
Acu-puncture, 339, 445, 1041.
Acu-puncture needles, 447, 1041.
Æsthesiometer for diagnosis, 382, 389.
After-working of electricity, 198, 203.
Agitans, 910, 988.
Ague-chills and fever, 469, 911.
Air-baths, electric, 400.
Albuminaria, test, 945, 1077.
Alcohol, pure spirits, 984, 988.
Amaurosis, 465, 797, 1016, 1022.
Amenorrhœa, atonic, 402, 466, 933.
*Anæsthesia*, 470, 479, 653, 740, 746, 751.
Anæsthesia, muscular, 653, 740.
Aneurism, electro-puncture for, 339, 1041.
Angina pectoris, 863.
Animal electricity in fishes, 161.
Animal electricity in man, 94, 172, 888.
Animal magnetism, 171.
Animation, suspended, 853.
Antispasmodics, true, 843, 863.
Aphasia, 465, 779.
Aphonia, or loss of voice, 771.
Apnœa, cardiac, 469, 865.
Apoplexy, brain, 665, 899.
Apoplexy, spinal, 719, 728.
Apparatus, electrical, 310–390.
Appendix of *formulæ*, 1087.
Appendix of *rules*, 460–471.
Applications of electricity, 392, 423, 460.
Artificial respiration, 433, 469, 858.
Asiatic cholera, 466, 974.
Asphyxia, 469, 666, 855, 932.
Astatic needle, 347.
Asthenic and Sthenic, 478, 530.
Asthma, nervous, 469, 863, 950.
*Ataxie, locomotrice progressive*, 795.
Atmospheric electricity, 35, 76.
Atony of bowels, 466, 926, 965.
Atony of liver, 469, 958.
Atony of uterus, 466, 921, 926, 929, 933.
Atrophy and progressive palsy, 676, 800, 1009.
Auditory nerve, 252, 1025.
Aura, electric, 315, 400.
Aura, epileptica, 893, 908.
Aural polypi, 1032.
Axillary nerves, 403, 463.

Back, pain in, 514.
Bath, electric air, 400.
Bath, electro-chemical, 377, 451.
Battery, action of, 338.
Battery, Becquerel's, 323.
Battery, Berzelius's, 322.
Battery, Bunsen's, 326.
Battery, compound, 323–325, 338.
Battery, constant, 319, 323, 324, 371.
Battery, Cruikshank's, 322.
Battery, Daniell's, 324.
Battery, dry and perpetual, 319, 323.
Battery, Duchenne's, 368.
Battery, faradaic, 344.
Battery, galvanic, 316, 320.
Battery, galvanic, (primary,) *different* from faradaic, (secondary,) 322, 379.
Battery, Grenet's, 327.
Battery, Grove's, 325.
Battery, Hall's constant, 371.
Battery, Humboldt's, 329.

Battery, Kidder's, 360.
Battery, Legendre and Morin's, 359.
Battery, *petit*, 321, 374.
Battery, Pulvermacher's chain, 117, 330.
Battery, Chester's, 331.
Battery, Rhumkorff's, 370.
Battery, Smee's, 329.
Battery, Thompson's, 328.
Battery, Volta's pile, 318.
Battery, Wollaston's, 322.
Battery, the water, 319, 323.
Bilious dyspepsia, 470, 682, 956.
Biology, electro, 109.
Bi-polarity of molecules, 189.
Bladder, neuralgia and palsy of, 466, 766, 1073.
Bladder, urinary, 276, 466, 766, 1069.
Blindness, 465, 1016.
Blood, effects on the, 278.
Blood-vessels, effects on, 277.
Blood-vessels, palsy of, 666, 674.
Bone, un-united fracture of, 446, 1047.
Bowels, affections of, 961, 963.
Bowels, atony of, 274, 961.
Bowels, constipation of, 961.
Bowels, weakness in, 965.
Brachial plexus, 557.
Brain apoplexy, 665.
Brain, diagnosis of, 663, 691, 1025.
Brain, diseases of, 234, 661, 883, 896, 915, 1025.
Brain, effects of electricity on, 231, 895.
Brain, exhaustion of, 674, 984.
Brain palsy, 663.
Brain softening, 661, 666, 674.
Brain, syphilitic disease of, 527, 646.
Breast milk, 469, 944.
Bright's disease, 477, 946.
Bronchocele, (goitre,) 1013.
By-workings of the current, 416.

Cardiac apnœa, 470, 865, 988.
Careless use of electro-*terms*, 395.
Carpo-pedal spasms, 460, 865.
Catalysis and electrolysis, 217.
Catamenia, 466, 932.
Catalepsy, 438, 460, 655.
Cauda equina, 243.
Cautery, dental, 1049, 1060.
Cautery electro, 327, 332, 343, 1049.
Centripetal and Centrifugal, 144.
Cephalalgia, 464, 483, 985.
Cerebellum, 237, 243, 915.
Cervico-brachial *region*, 506, 554.
Cervical neuralgia, 465, 470, 550.
Cervical palsy, 463, 550.
Cervical plexus, 543, 550.
Cervical rheumatism, 465, 550.
Chemical galvanic action, 316.
Chemical state of muscles, 135.
Chewing and smoking tobacco, 993.
Children's palsy, 469, 782, 882, 884.
Chills and fever, 469, 911.
Chloroform poison, 849.
Chlorosis, 466, 939.
Cholera, Asiatic, 469, 974.
Chorea, (St. Vitus's dance,) 469, 869
Chronic alcoholism, 469, 987.
Chronic atonic dysentery, 469, 972.
Chronic convulsions, 883.
Chronic disease of joints, 994.
Chronic muscle-pains, 469, 492.
Chronic neuralgia, 461, 481, 596.
Chronic rheumatism, 460, 612, 640,
Cilio-spinal *region*, 248.
*Circle* movements of electrodes, 427, 518.
Circulation of the blood, 278.
Clavus hystericus, 503.
Clouds, atmospheric electricity, 36.
Clouds, thunder, 37.
Coccygian gland, 248.
Coccyx, 242.
Cœlialgia, 470, 487.
Cold feet and hands, 982.
Colic, 833.
Colica pictonum, 469, 470, 588, 833.
Compound batteries, 359.
Concussion of nerves, 817.
Conduction, electric, 334.
Conduction of nerves, 150.
Conductors and non-conductors, 334.
Congestion of brain, 464, 915.
Congestion of spinal cord, 469, 719,
Constipation, atonic, 468, 963.
Consumption, 950.
Contraction of muscles, 134, 1010.
Convulsions, 860, 882, 884.
Convulsions, epileptic, 469.
Convulsions, hysterical, 881.
Coördination of movements, 795.
Coxalgia, (hip disease,) 468, 470.

Cramps, 861, 977.
Cramp, writers', 861.
Craniology, 236.
Crural (femoral) nerve, 572.
Crural neuralgic *region*, 571.
Cupping glasses, *oval* and *oblong*, 456.
Current breaker, 388.
Current conduction, 334, 336.
Current direction, 334, 337, 358, 424.
Current, electric, 222, 338, 358.
Current, *extra*, 370.
Current native in muscles, 183.
Current native in nerves, 192.
Current, *primary*, 316.
Current, *secondary*, 344.
*Cutis anserina*, 679, 912.

Deafness, nervous, 1025.
Death, apparent, reviving from, 423, 469, 855.
Death by lightning, 64, 67.
Death, hour of, 67, 74.
Debility, nervous, 469, 954.
Decline, the beginning of, 469, 950.
Delirium, 464, 475, 945, 987.
Delirium tremens, 464, 475, 987.
Dental surgery, 464, 1053, 1060.
Dentists' electrodes, 388, 390.
Dentists' use of electricity, 753, 1053, 1060.
Diagnosis, electric probe for, 1084.
Diagnosis, electro, for metal in wound, 1083, 1084.
Diagnosis, electro, in brain disease, 382, 689, 691, 693, 706.
Diagnosis, electro, in disease of uterus, 1082.
Diagnosis, electro, in facial palsy, 752.
Diagnosis, electro, in nerve injury, 382, 718, 1001, 1082.
Diagnosis, electro, in neuralgia, 529, 533.
Diagnosis, electro, in reflex palsy, 382, 743.
Diagnosis, electro, in rheumatism, 613.
Diagnosis, electro, in spinal disease, 382, 717, 734, 740, 902.
Diagnosis, electro-muscular, 382, 831
Diagnosis in pain, 488.
Diagnosis of nerve injury, 718, 1001, 1082, 1083.
Diaphragm, spasms of, 470, 865.
Diarrhœa, (atonic,) 466, 469, 972.
Di-polar molecules, 190.
Diphtheritic palsy, 822.
Direction of the current, 337, 358, 460, 688.
Direct faradaization, 440.
Directors, poles, electrodes, 358, 385, 390.
Discharger, electric, 313.
Discovery in electro-physiology, 122–309.
Discovery of electricity, 83.
Discovery of electrotome, 354, 361.
Discovery of faradaism, 88, 344.
Discovery of galvanism, 93.
Discovery of the Leyden jar, 85, 312.
Discovery of the voltaic pile, 96, 318.
Diseases, epidemic, 70, 75, 974.
Dismenorrhœa, 468, 933, 984.
Dolor spinalis, 460, 639.
Dorsal *region*, 563.
Double-circle movements, 427, 468.
*Down-running* current, 424, 460, 688, 862, 891, 924.
Down-toning currents, 407, 460, 891, 903.
Dropsy, 634.
Drowning, to resuscitate from, 855.
Dry grand-cupping, 455.
Duchenne's electric machine, 368.
Duchenne's "*method*," 345, 426, 438.
Dumb-ague, 913.
Dying nerve, 149.
Dyspepsia, nervous and atonic, 470, 478, 682, 839, 954.
Dyspnœa, 465, 470, 864, 988.
Dynamic electricity, 33.

Ear, diseases and treatment of, 1025.
Ear, effects of electricity on, 252, 390.
Ear electrodes, 390.
Early or late rigidity, 703.
Eclampsia, 884.
Eczema, nervous, 1009.
Effects of alcohol, 984.
Effects of atmospheric electricity, 38, 64, 70, 75.
Effects of heat and cold on nerves, 214.
Effects of tobacco, 948, 989.
Electric air-bath, 400.
Electric atmosphere changes, 39.
Electric attraction and repulsion, 25, 28.
Electric aura, 315, 400.
Electric cautery, 327, 388, 1049, 1060.
Electric conductor, 334, 338.
Electric currents, primary, 222, 338.

Electric currents, secondary, 358.
Electric eel, 164.
Electric fishes, 161.
Electric heat, 29, 327, 343, 388.
Electric magneto, 377.
Electric moxa, 330, 1040.
Electric remedy for poisons, 842.
Electric shocks, 402.
Electric sparks, 401.
Electric torpedo, 161.
Electrical apparatus, 310, 344.
Electrical apparatus, three classes of, 310.
Electrical battery, 338.
Electrical chair and stool, 311.
Electrical instruments, 310–390.
Electrical slippers, 388.
Electricity, animal, 161, 172, 888.
Electricity, application of, 392, 460.
Electricity, atmospheric, 57, 70.
Electricity and the blood, 278.
Electricity and the blood-vessels, 277.
Electricity and the brain, 231.
Electricity and the contractile fibre-cells, 290.
Electricity and the intestines and uterus, 274.
Electricity and the motor nerves, 143, 260.
Electricity and the muscles, 127, 187, 292.
Electricity and the nerve current, 172, 192.
Electricity and the organs of digestion, 470, 478, 682.
Electricity and the organs of hearing, 252, 390, 1025.
Electricity and the organs of sensation, 146, 256.
Electricity and the organs of sense, 249.
Electricity and the organs of sight, 1015.
Electricity and the organs of smelling, 255.
Electricity and the organs of secretion, 274.
Electricity and the organs of tasting, 256.
Electricity and the sentient nerves, 146, 256.
Electricity and the spinal cord, 244.
Electricity and the sympathetic nerves, 263.
Electricity and the uterus and ovaries, 274, 927, 1082.
Electricity, chemical action of, 93, 320.
Electricity different from magnetism, 54.
Electricity, dynamic, 33, 212.
Electricity, early history of, 83, 104.
Electricity, effects of, 38, 64, 391–471.
Electricity, effects of, on the frog, 95, 18 187.
Electricity, faradaic, (secondary,) 358.
Electricity, Franklin's theory of, 28.
Electricity, friction, laws of, 310, 333.
Electricity, galvanic, (primary,) 222, 33
Electricity, method and rules of, 310–47
Electricity, natural, 25.
Electricity, nature of, 28.
Electricity, sources of, 26.
Electricity, static, 31.
Electricity, thermo, 29.
Electrifying, 400, 423, 460, 464.
Electrized, 333, 400, 423, 460.
Electro-biology, 109.
Electro-cautery, 827, 332, 388.
Electro-cautery for teeth, 1059.
Electro-chemical bath, 451.
Electro-diagnosis, 691, 734.
Electro-dynamics, 212.
Electro-magnet, 357.
Electro-magnetic apparatus, 344.
Electro-magnetic vibrator, 354, 361.
Electro-medical *terms*, 395.
Electrometer, for testing, 187.
Electro-motory power, 318, 487.
Electro-muscular action, 292, 706.
Electro-muscular test and diagnosis, 3 691, 706, 831.
Electro-physiology, 109, 152, 292, 699.
Electro-physiology, laws of, 109–309.
Electro-physiology of muscles, 292.
Electro-physiology of nerves, 122, 187.
Electro-puncture, method of, for ane rism, 339, 445.
Electro-puncture, method of, for neur gia, 446.
Electro-puncture, method of, for rhe matic indurations, 446, 625, 1041.
Electro-puncture, method of, for sciati 445, 644, 1068.
Electro-therapeutics, 25, 104.
Electro-tonus, 184, 193, 202, 903.
Electrodes, 385–390, 440, 445.
Electrolysis and Catalysis, 217.
Electrotome, 354, 361.
Elementary fibres of muscles, 131.
Elementary fibres of nerves, 122, 138.

*Element* of battery, 318, 338.
Embolism, 684, 668.
Emissions, seminal, 466, 1071.
Emmenagogue, 938.
Emotion, seat of, 240.
Epigastralgia, 484.
Epilepsy, malarial, 894.
Epilepsy of the heart, 876.
Epilepsy, treatment of, 878, 884, 909.
Epileptica aura, 893, 908.
Erethism, 680.
Essential paralysis of children, 786, 803.
Eye, nervous affections of, 722, 754, 1015.
Eye, painful, 1015.
Eye, paralysis of, 754, 1015, 1025.
Eye, strained, 1015.
Exalted nerve action, 472, 903.
Excito-motor nerve power, 903.
Extra current of induction, 368, 373, 382.
Extra-polar working, 411.
Extra-polar current, 368, 370, 373.

Face rheumatism, 635.
Facial muscles, 293.
Facial nerve, (portio dura,) 433.
Facial neuralgia, 503, 543, 984.
Facial palsy, 752.
Facial spasm, 861.
Facial, tri-, (fifth pair,) 436.
Faradaic apparatus, 344.
Faradaic (induction) currents, 141, 358.
Faradaic tooth extraction, 1053.
Faradaism differs from galvanism, 316, 379.
Faradaization, 345, 426, 438, 697.
Faradaization of the diaphragm, 444.
Faradaization of the eyes and tongue, 443.
Faradaization of the face, 441.
Faradaization of the hand, 368.
Faradaization of the larynx, 368.
Faradaization of the shoulder, 441.
Faradaization of the skin, 442.
Faraday's discovery and views, 139.
Fatty degeneration of muscles, 446, 676, 786.
Feigned *Doctors*, 981.
Feigned nervous affections, 979.
Femoral nerve, (crural,) 572,
Fever and ague, 911.
Fibre-cells and electricity, 287.
Fish, the electric torpedo, 162.
Fish, the electric eel, 164.
Fits, eclampsia, 877, 884, 887.
Five kinds of sensibility, 720.
Flesh-mellowing, 453.
Flesh-worm palsy, 826.
Flooding, electricity for, 923.
Foot-board for electric current, 388.
Foot, nerves of, 24, 577, 578.
Fracture of bone, un-united, 1047.
Franklin's theory of electricity, 28.
Friction electricity, 311.
Frog, Galvani's, 95.
Frog, galvanoscopic, 187.
Frog, preparation of, 180.

Galvanic chemical action, 316.
Galvanic circuit, 340.
Galvanic suppository, 1082.
Galvani's discovery, 93, 104.
Galvani's frog, 95.
Galvanism — apparatus and batteries, 316, 320.
Galvanism — cautery, 327, 332.
Galvanism, chain for, 117, 330.
Galvanism, current of, 222, 340, 379.
Galvanism differs from faradaism, 316, 379.
Galvanism — electricity, 320.
Galvanism, history of, 93.
Galvanism, methods for using, 403, 460, 688.
Galvanism — needles, 447.
Galvanism of quantity or intensity, 340.
Galvanism — poultice, 331.
Galvanism — puncture, 445, 1041.
Galvanism, (voltaism,) 93, 222, 316.
Galvano-cauterizers, 327, 388, 1060.
Galvano-cautery, 327, 343, 1049, 1060.
Galvano-puncture, 339, 445, 446, 1041.
Galvano-puncture for aneurism, 339, 445.
Galvanometer, 182, 187, 188.
Galvanometer, tests by, 183.
Galvanoscopic frog, 187.
Ganglionic anæsthesia, 518, 523.
Ganglionic hyperæsthesia, 945, 983.
Ganglionic nerves, 263, 272, 912.
Garratt's pattern for electrodes, 385–390.
Gastric nervous affections, 470, 484, 954.
General principles, 392, 397, 460.
Geography of the nerves, 24, 543–580.
Genital organs, 435, 466, 1069.
Genito-crural region, 568.
Glossy skin, 1008.

Goitre, (bronchocele,) 1013.
Gout, 460, 602.
Gonorrhœal rheumatism, 632.
Grand dry-cupping, 455.

Hallerian irritability, 127.
Hand, muscles and nerves of, 812, 831.
Headaches, 464, 478, 483, 518, 524.
Headaches, chronic, 520.
Headaches, hemicrania, 525.
Headaches, hyperæmic, 524.
Headaches, hyperæsthetic, 521.
Headaches, profound, 520.
Headaches, sick, 527.
Headaches, symptomatic, 526.
Headaches, syphilitic, 527.
Headaches, treatment, 464, 529.
Hearing, 252, 1025.
Heart, affection of, 682, 713, 945.
Heart, effects of electricity on, 277.
Heart, nerves of, 279, 469.
Heat and cold, effects of, 214.
Heat, electric, 343.
Helix for induction currents, 354.
Hemiplegia, 663, 691–714, 720, 726.
Hemicrania, or megrim, 464, 503, 525.
Hickups, 860.
Hip disease, 468.
Hip joint, 505, 574, 590, 644, 808.
History of galvanism, 93, 104.
History of medical electricity, 83, 104.
Hydrocele, 1067.
Hydrophobia, 467, 866.
Hyperæsthesia, 470, 472, 474, 479, 522, 1008.
Hyperæsthesia, ganglionic, 983.
Hyperæsthesia of the back, 483.
Hyperæsthesia of the bladder, 487.
Hyperæsthesia of the bowels, 487.
Hyperæsthesia of the ears, 505.
Hyperæsthesia of the eyes, 505.
Hyperæsthesia of the head, 475, 483, 522.
Hyperæsthesia of the heart, 477.
Hyperæsthesia of the joints, 495.
Hyperæsthesia of the limbs, 488, 492.
Hyperæsthesia of the muscles, 483–492.
Hyperæsthesia of the ovaries, 487.
Hyperæsthesia of the skin, 472.
Hyperæsthesia of the stomach, 477, 483.
Hyperæsthesia of the teeth, 505.
Hyperæsthesia of the urethra, 1071.
Hyperæsthesia, traumatic, 1008.
Hypochondria, 478, 512, 682.
Hysteria, 442, 467, 479, 524.
Hysteria, local, 517.
Hysteria, the fit, 442, 512, 877, 907, 988.
Hysterical convulsions, 878, 881, 907, 9
Hysterical joints, 471, 761, 766, 994.
Hysterical neuralgia, 483–491.
Hysterical reflex palsy, 442, 467, 759, 7

Ice, application of, 863, 894, 975.
Idiopathic tetanus, 869.
Incontinence of urine, 276, 466, 1069.
Incurable rheumatism, 645.
Indigestion, nervous, (dyspepsia,) 470, 47
682.
Indolent ulcers, 330, 1038.
Induced (secondary or faradaic) electri
ty, 344.
Induration, rheumatic.
Inertia of uterus and abdomen, 466, 9
965.
Inflammation,
Inflammation of brain, 661.
Inflammation of nerves, 591.
Inflammation of spinal cord, 715.
Inhibitory nerve-action, 270, 923.
Infra-mammary pain, 506, 513.
Injury of nerves, 150, 582, 1003.
Insanity with palsy, 676.
Instruments and apparatus, 310.
Insulating chair and stool, 314.
Intensity and quantity currents, 339.
Intercostal neuralgia, 506, 564.
Intermitting fever, 911.
Intestines, 274, 512, 961.
Intestines, atony of, 466, 961, 965.
Intra-polar effects, 411.
Inveterate lameness, 446, 640, 808.
Involuntary movements, 872.
Iris, effects of electricity, 251.
Iritis, rheumatic.
Iritis, syphilitic.
Irritability of nerves, 148, 201.
Irritability, Hallerian, 127.

Jaundice, treatment of, 957.
Jaws, nerves of the, 433, 436.
Jaws, pains in, 635.
Jelly-like discharges, 968.
Joints, gouty and syphilitic, 998.

Joints, hysterical, 495, 761, 766, 995.
Joints, inflamed, 998, 1005.
Joints, painful, 495, 995, 1005.
Joints, rheumatic, 994, 998.
Joints, stiff, 497, 995, 1006.
Joints, swelled, 994.
Joints, syphilitic, 998.
Joints, treatment of, 863, 994, 1005.
Joints, "white swelling" of, 994.
Joints, weak, 995.

Key-board for the primary, 384.
Kidney affection cause of palsy, 743.
Killed, apparently, 855.
Killed by lightning, 67.

Labile and Stabile working, 408, 413.
Labile (wavy) muscle action, 414.
Lactescent, (breast-milk,) 944.
Lame arm, chronic, 596, 640, 807.
Laryngeal atony, (see *Aphonia*,) 771.
Laudanum poison, 848.
Laws of damage by lightning, 62, 64.
Laws of electro-pathology, 393.
Laws of electro-physiology, 391–471.
Laws of faradaism, 257, 393.
Laws of galvanism, 223, 392.
Laws of muscle contraction, 142.
Laws of nerve irritation, 141, 148.
Laws of primary current action, 223, 393.
Laws of reflex action, 270, 669.
Lead colic, 833.
Lead palsy, 828.
Leg, muscles and nerves of, 24, 809, 811.
Leucorrhœa, atonic, 466, 936.
Leyden jar, 312.
Lightning, 61, 89.
Lightning, effects of, 64.
Lightning, safety from, 62.
Liquors, pure spirits, effects of, 984.
Liver affections, 957.
Loadstone as a remedy, 380.
Local hysteria, 471, 517, 766, 994.
*Localized* faradaization, 404, 426, 438.
Local palsy, 751.
Locked-jaw, 869.
Loin muscles, 303.
Loin nerves, 567.
Loin pains, 467, 584.
Loss of voice, (aphonia,) 771.
Lumbago, 467, 508, 584, 612.
Lumbo-sacral region, 566.
Lungs, consumption of, 950.

Magnetism, animal, 161, 171.
Magnetism different from electricity, 54.
Magnetism, electro, 376.
Magneto-electricity, 376.
Magnets as a remedy, 380.
Malarial diseases, 469, 911.
Malarial epilepsy, 894.
Mania a potu, 475.
*Map of surface nerves*, 24.
Median nerve, 557, 559.
Medulla oblongata, 231, 897, 915.
Melyalgia, 488.
Meningitis, chronic, 661, 883.
Menorrhagia, atonic, 933.
Mercurial palsy, 910.
Mercurial trembling, 910.
Meteoric epidemics, 41.
Meteorology, 38.
Method for electrifying, 423, 460.
Method for faradaic electricity, 423, 460.
Method for faradaizing, 426, 470.
Method for galvanic electricity, 403, 460.
Method for neuralgia, 460, 470, 532.
Method for static electricity, 400.
Method for the abdomen, 434.
Method for the brain, 432, 465.
Method for the bladder, 276, 1069.
Method for the ear, 252, 430.
Method for the eyes, 432, 443.
Method for the face, 441, 464.
Method for the genitals, (male,) 435.
Method for the muscles, 428.
Method for the nose, 431.
Method for the rectum, 436, 1080.
Method for the skin, 427, 442.
Method for the throat, 433.
Method for the tongue, 431.
Method for the urethra, 1069.
Method for the uterus, 466, 922, 1082.
Method for the vital organs, 433.
Methods and Rules, 391, 423, 460–471.
Midwifery, 466, 921.
Milk secretion, and to dry, 944.
Mimosa, sensitive, 129.
Motions, muscular, 134.
Motions, organic, 120.
Motor nerves, 260.
Moxa, electric, 330.

Mucous dyspepsia, 956.
Muscæ volitantes, 1024.
Muscle fibres, 138, 288.
Muscle soreness, 484, 492.
Muscle trembling, 475, 910, 988.
Muscles, 292.
Muscles, atrophy or wasting of, 1009.
Muscles, contractions of, 134, 1010.
Muscles, cramps of, 860, 1008.
Muscles, exhausted, 135, 492.
Muscles of the back, 296, 300, 658, 788.
Muscles of the back of thigh, 812, 831.
Muscles of the body, 302, 303, 657.
Muscles of the front of thigh, 128, 810.
Muscles of the front of leg, 810.
Muscles of the face, 293.
Muscles of the hand, 812, 831.
Muscles of the hip, 128, 808.
Muscles of the hip and joint, 303.
Muscular anæsthesia, 1009.
Muscular contractility, 695, 707.
Muscular hyperæsthesia, 484, 492, 1009.
Muscular sensibility, 695.

Natural electricity, 25.
Neck, wry, 862.
Needle, acu-puncture, 339, 445, 447.
Needle, astatic, 347.
Needle, electro-puncture, 445, 447, 1041.
Needle, galvanometer, 187.
Negative electricity, 28, 314, 333, 337.
Negative electrodes, 314, 337.
Nephralgia, 467, 588
Nerve action, inhibitory, 270, 923.
Nerve, auditory, 252.
Nerve conduction, 150, 201, 660, 803.
Nerve current, 192, 201, 210.
Nerve, dying, 149.
Nerve, spinal, 126, 904.
Nerve, facial, 543, 546.
Nerve fatigue, 507.
Nerve force, 210, 888.
Nerve ganglia, 272.
Nerve injury, 150, 582, 660, 1003.
Nerve irritability, 148, 201, 888, 904.
Nerve, median, 557, 559.
Nerve molecules in action, 190.
Nerve molecules at rest, 191.
Nerve, peroneal, 576.
Nerve, pneumogastric, 477, 554.
Nerve polarization, 189, 888.
Nerve, popliteal, 575.
Nerve, posterior tibial, 576.
Nerve, sciatic, 574.
Nerve, sentient, 256.
Nerve structure, 122, 138.
Nerve suture, 1012.
Nerve, sympathetic, 268, 477, 888.
Nerve, vagi, 280.
*Nerves, map of surface*, 24.
Nerves, (*first pair*,) olfactory.
Nerves, (*second pair*,) optic.
Nerves, (*third pair*,) motor oculi.
Nerves, (*fourth pair*,) pathetic.
Nerves, (*fifth pair*,) tri-facial, 546, 54
Nerves, (*sixth pair*,) abducens oculi.
Nerves, (*seventh pair*,) portio dura, *facial*, 543.
Nerves, (*eighth pair*,) auditory, 252, 5
Nerves, (*ninth pair*,) glosso-pharyng 291, 554.
Nerves, (*tenth pair*,) pneumogastric, vagus, 477, 554.
Nerves, (*eleventh pair*,) spinal access 543.
Nerves, (*twelfth pair*,) hypoglossal, 5
Nerves, cervico-brachial, 24, 554.
Nerves, dorso-intercostal, 24, 563.
Nerves, facial, 24, 543.
Nerves, femero-crural, 24, 572.
Nerves, geography of, 543–580.
Nerves, intercostal, 24, 563.
Nerves, lumbo-sacral, 24, 566.
Nerves, mixed, 259.
Nerves, occipito-cervical, 543, 550.
Nerves, sciatica-femoral, 24, 571.
Nerves, sentient, 24.
Nerves of hearing, 252, 1025.
Nerves of motion, 138, 260.
Nerves of seeing, 548.
Nerves of sensation, 256.
Nerves of tasting, 256.
Nerves of the arm, 24, 508, 557, 560.
Nerves of the foot, 24, 577, 578.
Nerves of the hand, 24, 559.
Nerves of the head, 24, 543, 546, 554.
Nerves of the leg, 24, 574, 577.
Nervous affections of the ear, 1025.
Nervous affections of the eye, 1015.
Nervous affections, reflex, 871, 872.
Nervous aphonia, 771, 989.
Nervous cough, 477, 988, 989.

Nervous dyspepsia, 470, 477, 680, 988, 989.
Nervous habit or condition, 537, 988, 989.
Nervous headaches, 477, 511, 988.
Nervous heart affection, 680, 988, 989.
Neuralgia, 464, 500.
Neuralgia, acute, 500, 590, 595.
Neuralgia, asthenic, 460.
Neuralgia, chronic, 461, 481, 596.
Neuralgia, facial, 464, 503.
Neuralgia, ganglionic, 511.
Neuralgia, intercostal, 469, 486, 492, 506.
Neuralgia, occipital, 465, 492, 506.
Neuralgia of the arm and shoulder, 461, 508.
Neuralgia of the bladder, 1075.
Neuralgia of the bowels, 470, 967.
Neuralgia of the heart, 469.
Neuralgia of the hip and leg, 460, 461, 508.
Neuralgia of the joints, 495, 998.
Neuralgia of the periosteum, 511.
Neuralgia of the skin, 470, 511, 514.
Neuralgia of the spine, 470, 514, 597.
Neuralgia of the stomach, 470, 477.
Neuralgia of the teeth, 464.
Neuralgia of the testes, 466, 508.
Neuralgia of the uterus, 466, 512, 921, 926.
Neuralgia, rheumatic, 461, 631.
Neuralgia, spinal, 483, 514, 597, 788.
Neuralgia, syphilitic, 461, 650.
Neuralgia, thoracic, 469.
Neuralgia, treatment of, 461, 464, 533.
Neuralgic dyspepsia, 477, 954.
Neuralgic headaches, 477, 518.
Neuralgic pains, 532, 547–580.
Neuralgic rheumatism, 532, 631, 862.
Neuralgic treatment, 423, 460, 529, 532.
Neuroma, 583.
Notes to Chapter V., — *Rules*, 459.
Numbness, 742, 746.

Objective and subjective sensations, 653, 668.
Observations, meteorologic, 38.
Observations of weather, 60.
Occipito-cervical muscles, 506, 550.
Occipito-cervical neuralgia, 550, 619.
Occipito-cervical region, 506, 550.
Occipito-cervical rheumatism, 619.
Odontalgia, (toothache,) 505.
Œdema, 634.
Œsophagus, 290.
One-way current, faradaic, 54, 358.
One-way current, galvanic, 54, 338.
Opacity of the cornea, 1019.
Opium poison, 848.
Organic ganglia, 272.
Organic molecular motion, 120.
Organs of circulation, 277.
Organs of digestion, 291.
Organs of generation, 435, 922, 1073.
Organs of hearing, 1025.
Organs of secretion, 274.
Organs of seeing, 249, 1015.
Organs of sense, 249.
Organs of smelling, 255.
Organs of tasting, 126, 256.
Organs with no nerves, 308.
Otalgia, (earache,) 505, 1025.
Otitis, chronic, 1030.
Ozone, Ozonoscope, 41.

Pain, 477, 482, 580, 639.
Pain, arthritic, 495, 808, 998.
Pain, chronic, or seated, 480, 492.
Pain from debility and fatigue, 492, 510, 988.
Pain from electrodes, 436.
Pain from inflammation, 591, 661, 715.
Painful palsy, 596, 640, 807.
Pain in the arms and hands, 461, 488.
Pain in the back and side, 483, 715, 788.
Pain in the bowels and bladder, 487, 977, 1073.
Pain in the eyes, 465.
Pain in the face, 464.
Pain in the head, 478, 483, 506, 988.
Pain in the heart region, 478, 486, 988.
Pain in the legs and feet, 460, 461, 488, 509.
Pain in the liver and spleen, 478, 486.
Pain in the loins and kidneys, 467, 508, 584.
Pain in the muscles, 486, 492.
Pain in the neck, 464, 505.
Pain in the shoulders, 462, 508.
Pain in the skin, (hyperæsthesia,) 470, 472, 474.
Pain in the stomach and diaphragm, 478, 484.
Pain in the thorax, 486, 487.

Pain, neuralgic, 478, 510.
Pain, rheumatic, 510.
Pain, spinal, 483, 514, 597, 1066.
Pain, traumatic, 582.
Paralysis, (palsy,) 659, 688, 691, 902.
Paralysis, agitans, 909, 988.
Paralysis, cause of, 660, 902, 988, 989.
Paralysis, diphtheritic, 822.
Paralysis, facial, 752.
Paralysis from lead, 828.
Paralysis, general, 654, 671, 676.
Paralysis, hemiplegic, brain, 688, 691, 896.
Paralysis, hysterical, 759.
Paralysis, local, 751.
Paralysis, mercurial, 910.
Paralysis of childhood, 782.
Paralysis of the arm, 617, 804, 828.
Paralysis of the back and spine, 714, 788.
Paralysis of the bladder, 766, 1073.
Paralysis of the ear, 430, 1025.
Paralysis of the eye, 1015, 1025.
Paralysis of the motor nerves, 428.
Paralysis of the penis, 435, 1069.
Paralysis of the rectum, 435, 1081.
Paralysis of the sentient nerves, 427, 470.
Paralysis of the skin, (anæsthesia,) 427.
Paralysis of the throat, 433, 771.
Paralysis of the tongue, 797.
Paralysis of the vocal cords, 433, 771.
Paralysis, paraplegic spinal, 714, 743, 902.
Paralysis, reflex, 744, 759.
Paralysis, rheumatic, 804.
Paralysis, shaking, 909, 988.
Paralysis, spasmo, 782, 902.
Paralysis, traumatic, 812.
Paralysis, wasting progressive, 676, 786.
Paralysis, urinary, 435, 743, 1069.
Paraplegia, 714.
Paresis, 654, 676, 679.
Pericarditis, 945.
Periosteal pains and indurations, 626.
*Petit mal*, 668, 886, 892.
Phrenology, 236.
Physiology, electro, 109.
Pile, voltaic, 318.
Plants, irritability of, 128.
Pleuralgia, 486.
Pleurodynia, 630.
Plexus, axillary, 403, 463.
Plexus, solar, 963.
Pneumogastric nerve, 291.
Pneumogastric neuralgia, 984, 988, 98
Points, or neuralgic spots, 543–580.
Poison, arsenical, 838.
Poison, chemical remedy for, 839.
Poison, lead or mercurial, 828, 834, 83
Poison, narcotic, 842.
Poison, opium, 842.
Poison, rum or whiskey, 987.
Poison, tobacco, 842, 989.
Polarity of molecules, 190.
Polarity of nerves, 189, 740.
Polar working of current, 411, 977.
Pole changer, *Rule* 9, 465.
Poles of battery, 318, 358.
Poles of galvanometer, 182.
Positive current, 337.
Positive electricity, 28, 314, 333.
Positive pole, 314, 337.
*Precautions*, 392, 988, 989.
Priapism, 732.
Primary and secondary currents, 222, 3
Primary (galvanic) electricity, 977.
Prognosis, electro, 691, 734.
Progressive atrophy, 786–797.
Progressive palsy, 676, 988, 989.
Progressive palsy in children, 786.
Progressive wasting palsy, 676, 786, 7
988.
Pro inductione parturiente, 932.
Prolapsus abdominis, 435, 963.
Prolapsus ani, 435, 1080.
Prolapsus uteri, 940.
Prolapsus vaginæ, 434.
Prostration of nervous energy, 682.
Pudic nerve, 569.
Pulsations, local, 516.
Pulmonary consumption, 950.
Puncture, acu-electro, 339, 446.

Quantity and intensity of current, 339.

Rachalgia, (neuralgia of spine,) 483.
Ramollissement, (softening,) 988.
Ranuncula, (under the tongue,) 1013.
Rectum, palsy of, 435, 1080.
Rectum, prolapsus of, 1081.
Referred sensations, 235, 589, 742, 988.
Reflex brain affections, 669.
Reflex nervous affections, 270, 669, 7
744, 759, 781, 818, 871.
Reflex, spinal, 743, 744, 818, 821.

*Regions* of the body, 269.
Regions, neuralgic, 543–580.
Remitting fever, 916.
Repair and waste of the system, 108, 112, 115, 984, 990.
Restoring the apparently dead, 855.
Resuscitation, 886.
Researches and creeds, 152.
Retention of urine, 1069.
Rheumatic bronchitis, 629.
Rheumatic carditis, 713, 945.
Rheumatic effusions, 615, 617.
Rheumatic head pains, 465, 520
Rheumatic indurations, 617.
Rheumatic inflammation, 607.
Rheumatic iritis, 650.
Rheumatic neuralgia, 862.
Rheumatic nodes and rigidity, 604.
Rheumatism, acute, 605, 662, 862, 946.
Rheumatism, arthritic, 495, 995.
Rheumatism, chronic, 612, 640.
Rheumatism, gonorrhœal, 650.
Rheumatism, incurable, 645.
Rheumatism, muscular, 532, 862.
Rheumatism, neuralgic, 461, 631.
Rheumatism, sciatic, 609.
Rheumatism, sub-acute, 611, 615.
Rheumatism, syphilitic, 650.
Rigidity, early and late muscle, 703.
*Rigor mortis*, 136.
*Rules* for, (same as *Methods*,) 460–471.
Rules and methods, 391, 459–471.
Rum poison, 984, 987.
Rush of blood to the head, 518, 523, 668, 988.

Safety from lightning, 62.
Saint Vitus's dance, (chorea,) 870
Sciatica, 509, 537, 574, 590, 644.
Sciatic nerve, 574.
Sciatico-femoral region, 571.
Scrofula rheumatism, 630.
Scrofulosis, 953.
Seance, (sitting,) 459.
Sea-sickness, 983, 984.
Secondary current, 345, 379.
Secretion, 274.
Seeing, 249, 1023.
Sensations, perverted, 900, 988, 1006.
Sensations, referred, 235.
Sensibility and irritability, 148, 720.
Sensibility, five kinds of, 720.
Sentient nerves, 256.
Sexual abuse, 671, 749, 1069.
Shakes, 913, 984.
Shaking palsy, 909, 988.
Shampooing, deep, 453.
Shock, electric, 356, 402, 471.
Shoulder joint, 640, 999.
Sitting, electric, (seance,) 459.
Skin altered, 1007.
Skin nerves, 126, 256.
Skin neuralgia, (hyperæsthesia,) 256, 472, 514.
Skin palsy, (anæsthesia,) 653.
Slipper electrode, 388.
Smelling, 255.
Smoking and chewing tobacco, 984, 989.
Softening of brain, 661, 666, 673, 674.
Softening of spinal cord, 295, 714, 729.
Solar plexus, 963.
Somnambulism, 477.
Soreness, muscle, or pain, 492.
Sparks given or taken, 401.
Spasmatode and Spasmatic, 905, 909.
Spasm, muscle-shortening, 1011.
Spasmodic diseases, 860, 893.
Spasmo-paralysis, 782, 902.
Spasms, carpo-pedal, 865.
Spasms, (convulsions,) 882, 902.
Spasms of diaphragm, 865, 984.
Spasms, facial, 681.
Spasms, traumatic, 582, 869.
Spermatic cord, neuralgia of, 467, 984, 1069.
Spermatorrhœa, 671, 749, 1069.
Spinal atrophy, 795, 800.
Spinal curvature, 514, 714, 1010.
Spinal congestive hemorrhage, 719.
Spinal cord and column, 242.
Spinal diseases, 514.
Spinal exhaustion, 743, 954.
Spinal inflammation, 715.
Spinal irritation, 460, 639.
Spinal meningitis, 661, 883.
Spinal muscles, 296, 300, 658, 788.
Spinal neuralgia, 483, 514, 597, 788.
Spinal palsy, 714, 743, 902.
Spinal rheumatism, 467, 508, 584, 612.
Spinal softening, 295, 714.
Spine, hysterical, 460, 483, 639.
Spirits, (pure liquors,) 984, 988.

Sprained joints, 1000.
Stabile, (steady,) 207, 408.
Static electricity, 31, 83, 333.
Steady current, 407, 427.
Stomach atony, (hyperæsthesia,) 682, 984.
Stomach nervous affections, 470, 682, 954.
Stomach sickness and pains, 984, 988, 990.
Storms, 50.
Strabismus, (squint,) 1017.
Strictures of the urethra, 1071.
Stuttering, 771.
Subjective and Objective sensations, 653, 668, 948, 988.
Sub-cutaneous electrodes, 445.
Sub-cutaneous injections, prescriptions for, (Nos. 31–33,) 1089.
Sub-luxation, 793.
Sudden death, 686, 990.
Suffocation, (asphyxia,) 469, 932.
Sun-stroke, 669.
Suppression of urine, 512, 1060.
*Surgery*, 994.
Surgery, electricity in, 994.
Suspended animation, 853.
Swelled joints, 994.
Sympathetic nerves, 263.
Syncope, 666.
Syphilitic nervous diseases, 527, 646, 893.
Syphilitic disease of throat, 1014.
Syphilitic headaches, 527.

Tabes dorsalis, 484, 799.
Tabes mesenterii, 434.
Taste, tongue, 126, 256, 1014.
Team-electrodes, (faradaizing,) 469.
Terms, careless use of, 395.
Test by æsthesiometer, 382, 389.
Test for animal electricity, 183.
Test for death, 859.
Test for palsy, 382, 752, 831, 902.
Tetanilla, 410, 868.
Tetanode and Tetanic, 904.
Thermo-electricity, 29.
Thigh muscles and nerves, 809, 810.
Thoracalgia, 487, 506.
Thrombosis, 506, 686, 761.
Thunderbolts, 62.
Thunder clouds, 37.
*Tic douloureux*, 464, 503.
Tobacco, its effects, 948, 989.
Tobacco, its effects on boys, 992.
Tobacco, its effects on the heart, 948.
To electrify, the method, 403, 423.
To electrify the abdomen, 433, 470.
To electrify the bladder, 434, 466, 470.
To electrify the brain, 432, 460.
To electrify the ear, 430, 460.
To electrify the eyes, 432, 460.
To electrify the male genitals, 435, 466 467.
To electrify the mouth, 431, 460.
To electrify the muscles, 428, 463.
To electrify the nerves, 403, 423, 460.
To electrify the nose, 431, 460.
To electrify the rectum, 435, 466.
To electrify the stomach, 469, 984.
To electrify the throat, 433, 469.
To electrify the uterus, 434, 466, 467.
To electrify the vital organs, 433, 469.
Tone down, 894.
Tonus, electro, 184, 193, 202, 463.
Toothache, 744, 1059.
Tooth extraction by electricity, 1053.
Torpedo, fish, 162.
Torticollis, 862.
Traumatic palsy, 812, 1001.
Traumatic tetanus, 869.
Treatment, faradaic, 423, 460.
Treatment, galvanic, 404, 460.
Tremblings in muscles and limbs, 909 988, 990.
Tremor, (agitans,) 909, 988, 990.
Trismus, 246, 868.
Tri-facial nerve, 543, 546.
Tuberculosis, 953.
Two-way current, (secondary,) 358.

Ulcers, indolent, 1038.
Un-united fracture of bones, 1047.
Up-running current, 424, 862.
Ureters, 276.
Urethra, 894, 1069.
Urethro-vaginal fistula, 1051.
Urinary bladder, 276, 1069.
Urinary bladder, neuralgia of, 512, 1069.
Urinary bladder, palsy of, 1060.
Urinary bladder, reflex palsy of, 743.
Urine, test of, 1078.
Uterine egg-and-stem electrode, 944.
Uterine prolapsus, 940, 1082.
Uterus, atony of, 466, 921, 933, 1082.

Uterus, misplacement of, 941, 1082.
Uterus, nerves of, 274, 466, 922, 927, 1082.
Uterus, neuralgia of, 512.
Uterus, undeveloped, 943, 1082.

Vaso-motor hyperæsthesia, 518, 522, 668, 945.
Vaso-motor nerves, 271, 277, 912.
Vaso-motor palsy, 518, 523, 651, 668, 723, 842, 885, 988, 990.
Vertigo, 667, 893, 988.
Vibrator, electro-magnetic, 354, 361.
Visceral atony, 274, 468, 961.
Visceral neuralgia, 468, 512.
Vital force, 117, 209.
Vitality, 117, 209.
Voltaic electricity, 317.
Volta's pile, 318.
Voice, loss of, 117, 209, 988.
Vomiting, choleric, hysterical, 988.

Wall-paper poison, 838.
Waste and repair of the body, 108, 115, 984, 990.
Wasting palsy, progressive, 676, 786, 1009.
Water battery, 323.
Wavy (*labile*) currents, 407.
Weather observations, 60.
Writer's cramp, 861.
Writer's palsy, 988, 990.
Wry neck, 862.
White swellings, 994.
White softening of brain and cord, 6
Wounded nerves, 150, 1001.
Wrist dropping, 828.

U871 Garratt, A.C.
G24 Medical electricity.
1866 7695

| NAME | DATE DUE |
| --- | --- |